Griff Hollow

[SP 361 895]

J.N. Carney and T.C. Pharaoh

Introduction

The Griff Hollow GCR site is situated within the Nuneaton inlier of pre-Devonian rocks (Bridge *et al.,* 1998). It is largely occupied by the Griff No. 4 aggregate quarry (Figure 5.6). The site has been selected because it exposes the type example of a composite hornblende diorite sill, one of a swarm of concordant bodies collectively termed the Midlands Minor Intrusive Suite (Carney *et al.,* 1992). The sill, about 50 m thick, is intruded into Upper Cambrian mudstone belonging to the Outwoods Shale Formation of the Stockingford Shale Group (Taylor and Rushton, 1971). Its emplacement age has been constrained at 442 ± 3 Ma by a U-Pb determination on baddeleyite from a pegmatitic segregation (Noble *et al.,* 1993). This late Ordovician (earliest Ashgill) age is similar to that determined for the South Leicestershire diorites exposed farther east.

The Midlands Minor Intrusive Suite differs from the South Leicestershire diorites in a number of important respects. The Griff Hollow composite sill is intimately associated with narrow sheets of fine-grained lamprophyre, a rock that is not associated with the South Leicestershire diorites. Petrographical studies further support the assertion made by Allport (1879) that the Nuneaton sills contain olivine and are thus devoid of essential quartz. Other significant geochemical differences exist between the two Ordovician intrusive suites (Bridge *et al.,* 1998). Therefore the site is important in comparative studies aimed at resolving the causes of both regional and local petrological variations within the late Ordovician (Caledonian) magmatic rocks of central England.

The NW corner of the quarry contains an exposure of the unconformity between the sill and overlying Coal Measures sandstones, providing field evidence for the pre-Carboniferous (Westphalian) age of the Midlands Minor Intrusive Suite.

Description

Igneous layering within the Griff Hollow sill dips at about 20° to the SW, parallel to the base of the sill and concordant with bedding in the Stockingford Shale Group. The host strata contain slumped bedding, but were evidently well consolidated at the time of intrusion; they are not spotted, but are flinty and hard for several centimetres from the contact.

The sole of the intrusion consists of a 20 cm-thick chilled zone of fine-grained spessartite lamprophyre. Abundant flow-aligned plagioclase laths are accompanied by a few per cent of small plagioclase and chloritized mafic phenocrysts. The base is much altered with interstitial chlorite and carbonate, which also fill small vugs. The lowest part of the sill in the SE of the quarry is replaced by a sheeted complex consisting of *c.* 1 m-wide lamprophyre sills interfin-gered with the host mudstone. These sills are texturally and mineralogically similar to the basal facies of the main part of the composite sill and to discrete lamprophyre sheets cutting the rest of the Griff Hollow intrusion.

Overlying the basal lamprophyre are 4–5 m of dark-grey, medium-grained hornblende mela-diorite characterized by a thickly developed planar foliation, parallel to the basal contact of the sill, and consisting of dark-grey diorite interlayered with a paler-grey, more feldspathic variety. The meladiorite is highly magnetic due to the presence of several per cent of iron-titanium oxides in the rock. Mafic minerals, comprising some 40% of the rock, consist of pale-yellow to brown euhedral hornblende, altered olivine and pyroxene. Euhedral plagioclase forms the remainder of the rock. The importance of volatiles in the late-stage crystallization of the intrusion is indicated by the occurrence of much interstitial chlorite, carbonate and pyrite.

Sharply succeeding the hornblende meladiorite is a layer of poikilitic hornblende meladiorite, about 22 m thick (Figure 5.7), which represents the most mafic-enriched part of the sill. In its lower part it is a highly distinctive black, pyritous, coarse-grained rock with hornblende crystals up to 25 mm long. The rock is dominated by areas in which large interlocking plates of dark reddish-brown hornblende poikilitically enclose highly altered olivine, clinopyroxene and plagioclase; the accessory minerals are iron-titanium oxides, apatite, and secondary actino-lite, chlorite, pyrite and pumpellyite. This facies passes up into a more plagioclase-rich meladiorite in which the clinopyroxene is fresher. In the middle to lower parts the poikilitic meladiorite layer contains sporadic elliptical pegmatitic segregations. These show cores enriched in pink albite intergrown with large crystals and aggregates of white mica, pyrite and carbonate. In the south-eastern part of the sill (Figure 5.7), the poikilitic hornblende meladiorite forms metre-long pods within the hornblende diorite.

The topmost facies of the sill, about 24 m thick, consists of pale-grey, pyritous, coarse-grained hornblende diorite with prominent white plagioclase and black hornblende laths.

Interpretation

The Griff Hollow intrusion contains the complete assemblage of lithologies found in composite diorite sills of the late Ordovician Midlands Minor Intrusive Suite. Lamprophyres that occur along the sole and within the main body of the intrusion are interpreted as the chilled equivalents of the magmas which formed the diorite sills.

Previously, all of the Nuneaton sills were described as camptonites (e.g. Lapworth, 1898; Le Bas, 1968), but Hawkes (in Taylor and Rushton, 1971) noted that the diopsidic nature of the pyroxene, sodic composition of the plagioclase and absence of any obvious alkaline mineralogy is more in keeping with a classification as the spessartite variety of lamprophyre. However, Hawkes was incorrect to suggest that olivine is absent. The presence of olivine is compatible with the recent classification of spessartite as advocated by Rock (1987). Recent studies have shown that hornblende compositions in the Griff sill range from edenitic to pargasitic (Bridge *et al.,* 1998), and these are also compatible with a spessartite lineage for the Midlands Minor Intrusive Suite magmas.

Vertical mineralogical variations within the sill indicate that the amount of olivine and pyroxene remains approximately constant between the hornblende meladiorite and the succeeding poikilitic hornblende meladiorite layer. The latter contains correspondingly larger amounts of interstitial hornblende, which suggests crystallization of a magma enriched in iron, magnesium and related elements. The coarse-grained, in places pegmatitic, texture of the poikilitic hornblende meladiorite further suggests relatively slow crystallization of hornblende in the presence of a volatile phase. These relationships show that in-situ fractionation involving mafic crystal accumulation is unlikely to have caused the compositional layering, and suggest that the intrusion formed by the multiple injection of related magma batches (Thorpe *et al.,* 1993). The field observations generally support multiple intrusion of these sills (e.g. Le Bas, 1968).

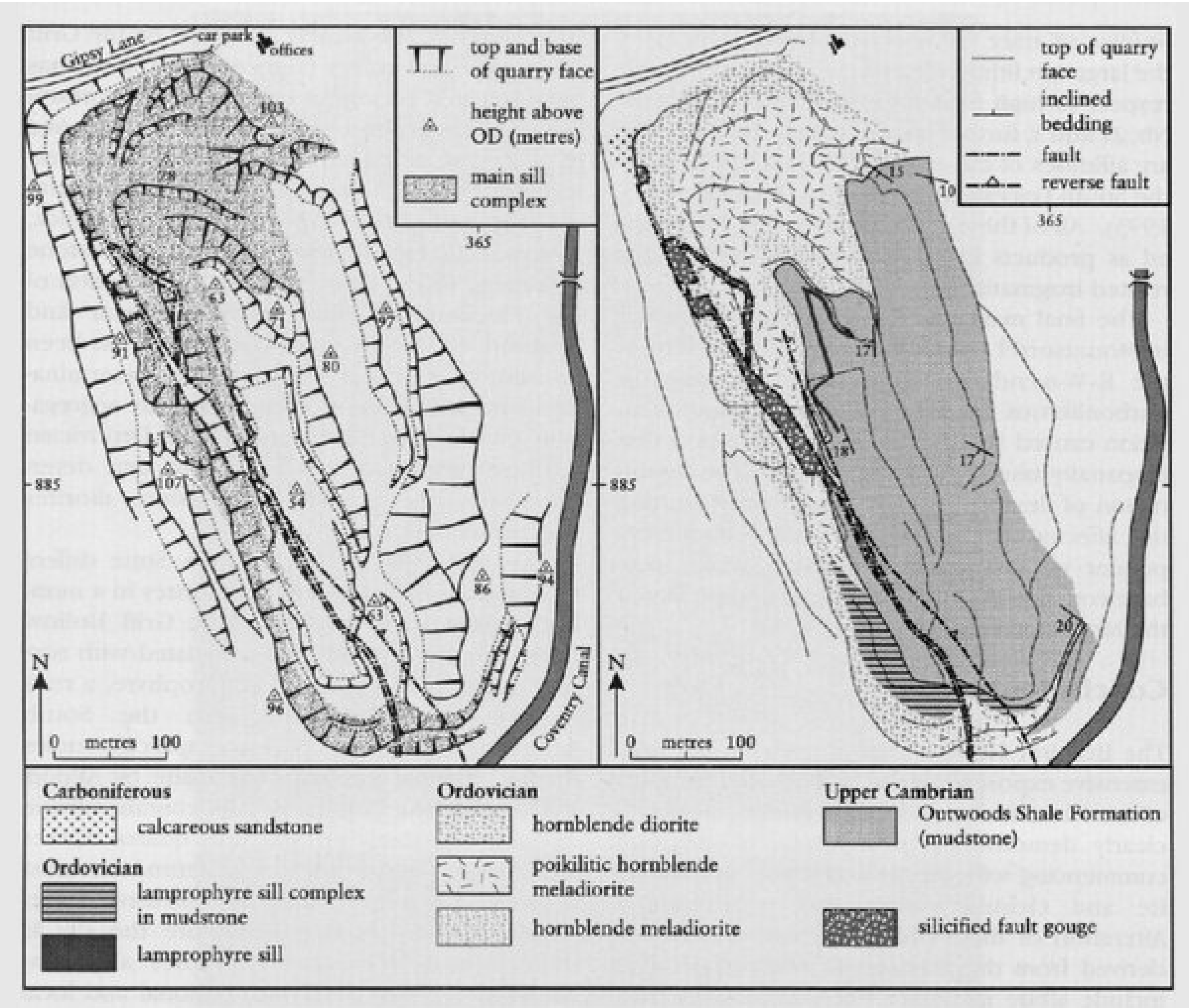
Geochemical data relevant to the petrological processes that contributed to the compositional diversity of the Griff Hollow sill are discussed in Thorpe *et al.* (1993) and Henney (in Bridge *et al.,* 1998). Henney showed that only one of the Griff Hollow rocks shows Eu enrichment, indicating that feldspar fractionation is unlikely to have occurred. Similarly, the values of MgO, Ni and Cr in most cases show a limited range indicating that they have undergone only minor fractionation, and in some rocks their abundances are comparable with those of unfractionated, primitive mantle-derived melts. Thorpe *et al.* (1993) also favoured a model involving low-degree, mantle-derived partial melting under volatile-rich conditions, with varying degrees of crystal fractionation of these liquids at the base of the crust or during ascent.

The tectonic setting of magma generation can be inferred from the geochemical data. Thorpe *et al.* (1993) noted that on the total alkali–silica diagram, the diorites and lamprophyres from Griff Hollow have an alkalic trend, with compositional affinities that span the basalt–trachyandesite fields and including types with normative olivine and hypersthene or nepheline. The rocks have high TiO_2 values relative to the South Leicestershire diorites, and Zr/Y and Zr concentrations appropriate to magmas generated in within-plate tectonic settings. However, the high La/Ta and Th/Ta ratios (Thorpe *et al.,* 1993), and high Ba/Ta (Henney, in Bridge *et al.,* 1998) also suggest the involvement of a subduction zone component in their genesis. It is considered probable that the Midlands Minor Intrusive Suite originated from lithospheric mantle previously enriched during Ordovician subduction, and subjected to low-degree partial melting during cessation of subduction. This occurred at a time when the accretion of Caledonian orogenic terranes had enlarged the Midlands cratonic crust (Thorpe *et al.,* 1993).

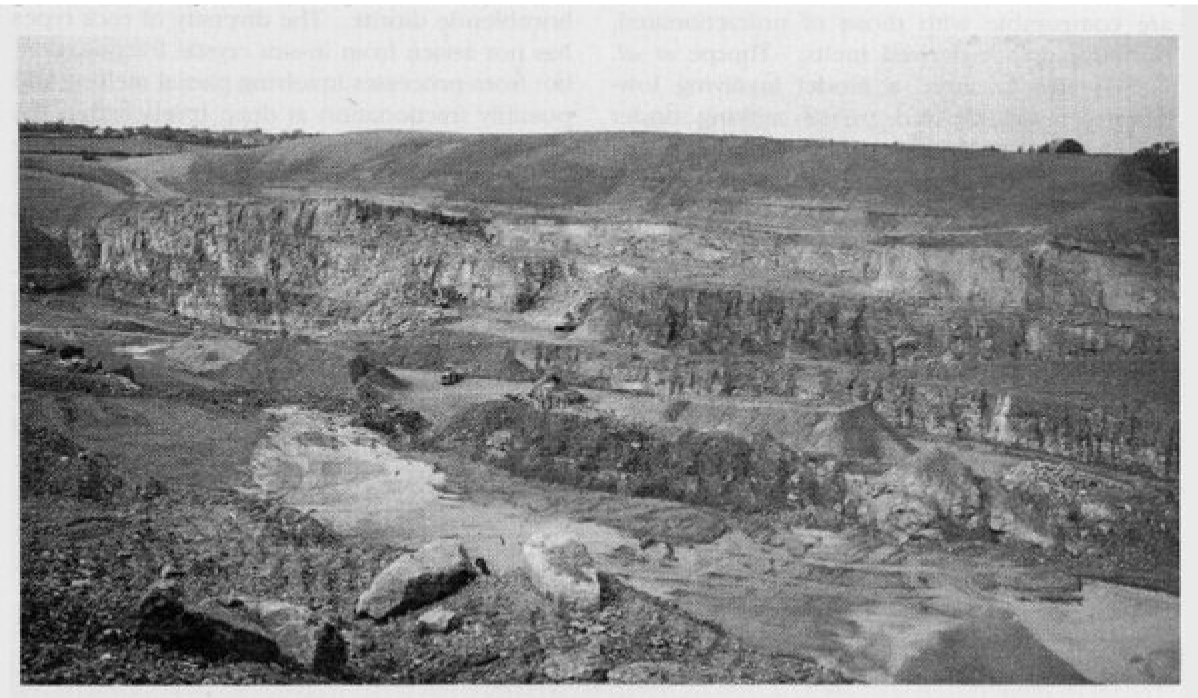
Conclusions

The Griff Hollow GCR site exposes diorites and lamprophyres belonging to the late Ordovician Midlands Minor Intrusive Suite, and emplaced into the Upper Cambrian Stockingford Shale Group. The site contains a typical example of a composite layered hornblende diorite sill, consisting of a lamprophyric sole, passing upwards into a hornblende-enriched facies and pale hornblende diorite. The diversity of rock types has not arisen from in-situ crystal fractionation, but from processes involving partial melting and possibly fractionation at deep levels within the crust or upper mantle, followed by the multiple intrusion of genetically related magma batches. The Griff Hollow sill belongs to essentially the same late Ordovician (Caledonian) magmatic episode as the quartz-bearing South Leicestershire diorites, but differs petrographically and geochemically, and may have been emplaced slightly later, when the tectonic setting of this region was undergoing transition from a subduction-controlled to a within-plate type of regime.

References



(Figure 5.6) Map of the Griff Hollow GCR site (modified from Bridge et al., 1998). Positions of quarry faces in 1990 are shown.



(Figure 5.7) View of the western face of Griff No.4 Quarry. The base of the sill is at the foot of the lowest face, behind the stockpile in the centre of the photograph. The middle face, dark-grey in tone, exposes the poikilitic hornblende meladiorite layer and the upper face is in pale-grey hornblende diorite. The regular bedding above the latter represents the Coal Measures unconformably overlying the sill. (Photo: J. N. Carney.)