Buddon Hill

[SK 562 154]

J.N. Carney and TC. Pharaoh

Introduction

The Buddon Hill GCR site comprises isolated rocky knolls in woodland to the north and east of the Swithland Reservoir and includes most of the central and western parts of the Mountsorrel roadstone quarry (Figure 5.4). Features that underline the importance of the site to studies of central England Caledonian magmatism include: the considerable extent of exposure, the variety of igneous rock types and contact relationships that they portray, and the more silicic nature of the Mountsorrel complex (Le Bas, 1968, 1972) compared with the otherwise compositionally similar Croft pluton (see the Croft Hill GCR site report). Geophysical studies indicate that the complex extends beneath younger cover rocks to the village of Thrussington, about 8 km to the east (Hallimond, 1930; McLintock and Phemister, 1931). Borehole provings also suggest that comparable granodioritic rocks are regionally developed (Pharaoh *et al.,* 1993).

Early workers thought the Mountsorrel rocks were part of the Precambrian Charnwood Forest massif (e.g. Hill and Bonney, 1878). Lowe (1926) drew attention to the predominantly granodioritic composition, whereas Jones (1927) suggested, on the basis of jointing, that they represent an intrusion of 'post-Charnian' age. Meanwhile, Watts (prior to publication in 1947) had concluded that the rocks have petrological affinities with the igneous 'Caledonian group' of the Lake District. This view was seemingly confirmed by Meneisy and Miller (1963), who obtained a K-Ar age of 379 ± 17 Ma on biotite from a diorite from Brazil Wood, to the SW of Buddon Hill. However, the emplacement age is constrained better by the U-Pb determination of 463 ± 32 Ma (early Caradoc) on zircon from the Mountsorrel complex (Pidgeon and Aftalion, 1978; recalculated by Noble *et al.,* 1993). The Caledonian age of the Mountsorrel rocks is in keeping with their strongly calc-alkaline geochemistry, comparable to some intrusions of the Brabant Massif of Belgium and the English Lake District (Le Bas, 1972; Pharaoh *et al.,* 1993). These rocks therefore provide evidence for Ordovician calc-alkaline magmatism in eastern England, probably associated with subduction of oceanic lithosphere from an eastern Tornquist branch of the Iapetus Ocean (Pharaoh *et al.,* 1993).

The site contains one of the few exposures of contact relationships between these plutonic rocks and cleaved, hornfelsed mudstone. Le Bas (1968) noted that the metasedimentary country rocks are more iron-rich, and less siliceous, than the Swithland Slates of the Precambrian Charnian Supergroup, and may instead correlate with Cambrian strata similar to the Stockingford Shale Group exposed around Nuneaton (e.g. Taylor and Rushton, 1971). However, there is no direct evidence to support either hypothesis.

A basic dyke, thought to belong to the late Carboniferous alkaline cycle of magmatism (Le Bas, 1968), and the highly irregular unconformable base of the Triassic strata are displayed within the Mountsorrel Quarry.

Description

The slopes above the NE shore of Swithland Reservoir [SK 5607 1461] expose pink-weathered, inequigranular coarse-grained biotite granodiorite which represents the voluminous, main phase of the Mountsorrel complex. Laths and euhedral plates of plagioclase (about 60%) are surrounded by hypidiomorphic-granular aggregates of albite, inclusion-filled perthitic alkali feldspar and clear quartz; the mafic minerals are mainly brown biotite and yellow to green hornblende. The granodiorite encloses sporadic pink to grey, rounded xenoliths of equigranular diorite averaging 50 mm across. It is cut by sheets of fine- to medium-grained aplitic microgranite between 10 mm and 0.15 m wide: similar late sheets are visible in exposures northwards along this slope, up to the wall of the dam.

North-cast of the dam the granodiorite is coarser grained and more inequigranular, a texture that is well displayed at the summit of the prominent knoll overlooking the spillway [SK 5575 1501]. This exposure exhibits two phases of aplitic intrusion (Figure 5.5); the first comprises a vertical sheet 0.45 m thick striking NNE and the second, a cross-cutting sheet dipping 40° to the NE. At the base of this knoll, to the west, in a small quarry is a pale-grey, mafic-rich 'basic granodiorite' (Le Bas, 1968), suggesting proximity to the margin of the pluton.

Contact relationships between granodiorite and country rock were described by Watts (1947) at the 'Old Gravel Pit' [SK 5582 1555], about 670 m NNE of the dam. At this locality, now much overgrown, purple, micaceous, hornfelsed mudstone is traversed by sinuous veinlets of pink granodiorite, and by sheets several centimetres wide of pink to grey, medium-grained equigranular 'basic granodiorite'. According to Watts (1947), the hornfels contains garnet and cordierite.

Granodiorite forming the eastern part of Mountsorrel Quarry appears relatively devoid of aplitic microgranite sheets and contains only sporadic, small rounded xenoliths of dark-grey medium-grained diorite. Farther west, aplitic sheets and xenoliths are more common, and two phases of intrusion can be recognized, the second accompanied by marginal chilling of the sheets. The fresh granodiorite is a grey, inequigranular, coarse-grained rock speckled with biotite. High-temperature alteration, which has caused reddening of feldspars and replacement of the mafic minerals, occurs in association with wide zones of closely spaced E–W orientated joints, the surfaces of which show slickenfibre development. Within the altered zones, King (1968) determined a lower temperature mineral assemblage of dolomite, epidote, chlorite, quartz, chalcopyrite and pyrite together with minor amounts of galena, calcite, haematite and baryte. The style of this mineralization is comparable to that seen at Shap in the Lake District (see the Shap Fell Crags GCR site report, Chapter 4).

A sub-vertical dolerite dyke 2–3 m wide crosses the quarry, following an approximately E–W course related to the trend of the principal fracture systems in the granodiorite. It is dark-green, medium grained and reminiscent in appearance to Carboniferous minor intrusions found in the region; the precise age is uncertain. In the eastern quarry face the dyke shows an apparent dextral offset along the NW fault which crosses the quarry. The western face exhibits an offset along an arcuate reverse fault dipping steeply to the NE. A second mineralizing event has filled joints parallel to the dolerite and consists of cavernous veinlets with dolomite, calcite, bitumen, a clay mineral and pyrite. A hydrother-mal origin for the bitumen was suggested by Sylvester-Bradley and King (1963), and Ponnamperuma and Pering (1966).

In the eastern face of the quarry an excellent example of a Triassic valley eroded into the granodiorite is preserved. The lower part of the valley is occupied by a breccia of granodiorite fragments, overlain by red and green parallel-bedded mudstone and siltstone.

Interpretation

The site exposes a variety of plutonic rocks near to the western margin of the Mountsorrel complex. Close to the contact, the exposures show that the plutonic rocks have veined the country rock, with the growth of garnet and cordierite in hornfelsed mudstone of possible Cambrian age.

The earliest phase of the Mountsorrel complex may be the dioritic xenoliths. These are possibly cognate inclusions derived from a basic precursor that was disrupted during intrusion of the main-phase biotite granodiorite, though other explanations are possible. The persistence of basic granodiorite close to the western contact of the pluton was attributed by Taylor (1934) to reaction between granodiorite and pre-existing diorite. A different interpretation was proposed by Le Bas (1968), who suggested that at Kinchley Hill, 450 m south of the site, the intrusive relationships indicate that granodiorite and diorite were contemporaneous, facilitating processes of hybridization that basified the former and acidified the latter. The main-phase biotite granodiorite was subsequently veined by at least two generations of aplitic microgranite sheets. These were interpreted by Taylor (1934) to be the relatives of a sodic 'aplogranite magma' which, after hybridizing at depth with gabbro or diorite, had given rise to the main body of granodiorite. Alternatively, the aplitic rocks could be differentiates of the granodiorite injected back into the partially cooled pluton. This late magmatic environment favoured the molybdenite mineralization seen in association with aplitic and pegmatitic rocks in other parts of the Mountsorrel complex (King, 1959, 1968).

The locally extensive low-temperature alteration of the Mountsorrel body was attributed to deuteric mineralization by King (1968), though it may also be related to the formation of E–W joint systems, implying an underlying tectonic control.

Major element geochemical data discussed by Le Bas (1972) demonstrate the calc-alkaline magmatic lineage of the Mountsorrel complex.

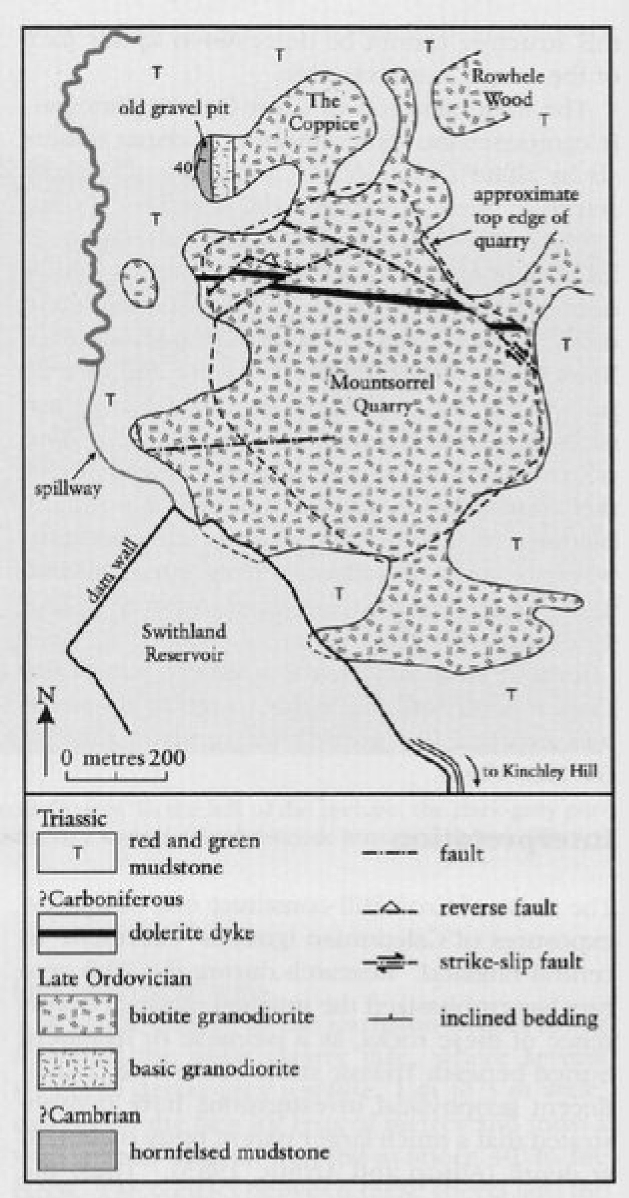
Studies of trace elements show enrichment of the large ion lithophile elements Th and Ce with respect to high field-strength elements such as Nb, Zr and Y, further confirming the calc-alkaline arc affinities of the complex and its similarity to the South Leicestershire diorites (Pharaoh *et al.,* 1993). All of these rocks are therefore interpreted as products of late Ordovician subduction-related magmatism.

The final magmatic event, uniquely exposed in Mountsorrel Quarry, was the emplacement of the E–W-trending dolerite dyke, possibly in Carboniferous times. Hydrothermal fluid circulation caused the low-grade mineralization that is spatially associated with the dyke. The combination of dextral strike-slip and reverse faulting that affected the dyke suggests a significant component of Variscan transpression which may have contributed to the structural complexity of the Mountsorrel pluton.

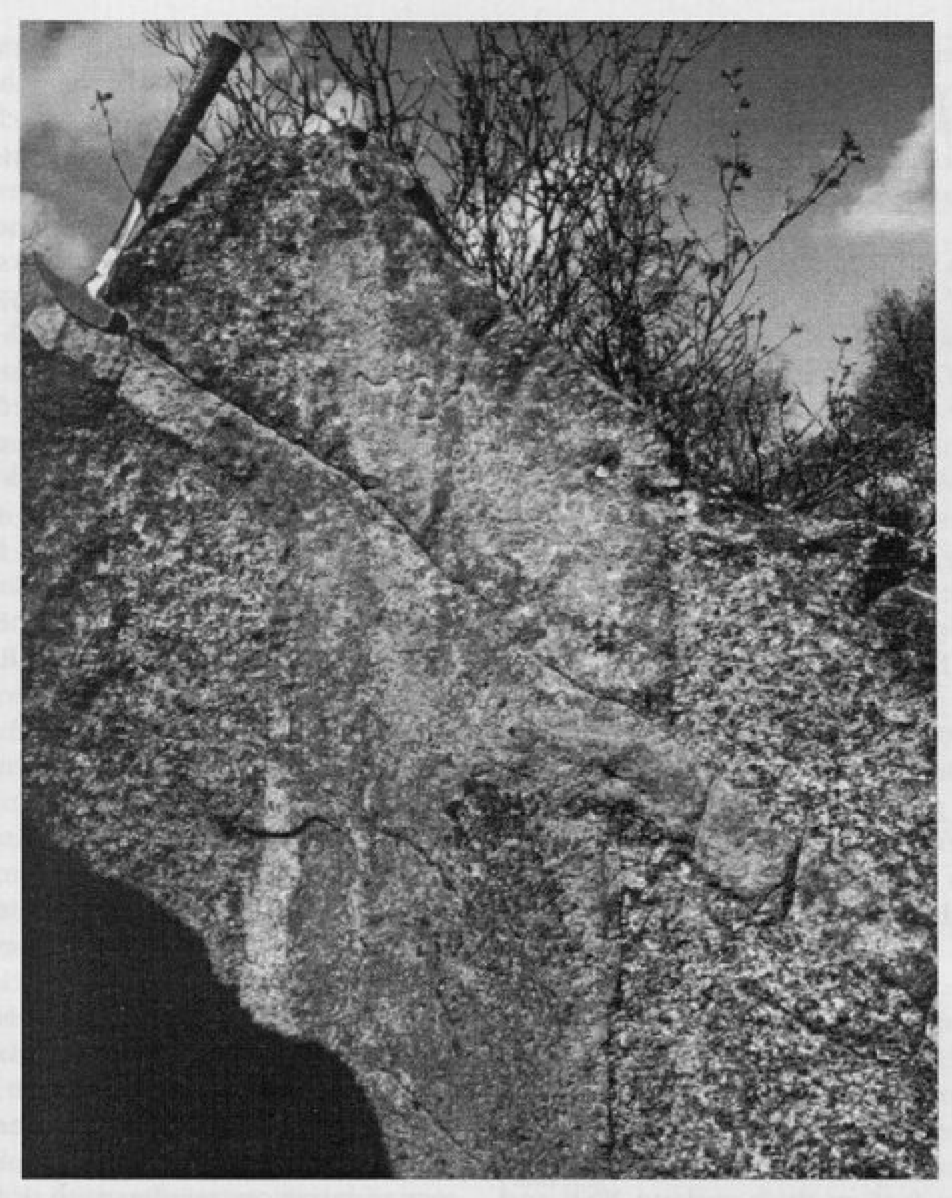
Conclusions

The Buddon Hill GCR site represents the only extensive exposures of the Mountsorrel complex of late Ordovician calc-alkaline plutonic rocks. It clearly demonstrates a sequence of intrusion commencing with diorite and biotite granodiorite and closing with aplitic microgranite. Alteration of these phases by water-rich fluids derived from the magmas, to assemblages that include albite may have been, at least in part, structurally controlled. One of the main features of the site is an exposure of the western contact of the complex. This shows granodiorite veining fine-grained metasedimentary rocks which have been converted to a garnet-cordierite hornfels. A dolerite dyke crossing the Mountsorrel Quarry may be Carboniferous in age; it has acted as a passive marker, illustrating a possible Variscan phase of deformation. The highly irregular unconformity at the base of the Triassic strata is preserved around the margin of Mountsorrel Quarry.

References



(Figure 5.4) Map of the Buddon Hill GCR site, based in part on BGS 1:10 560 scale mapping.



(Figure 5.5) Exposure of granodiorite at Buddon Hill showing two phases of aplite intrusion. (Photo: T. C. Pharaoh.)