Judkins' Quarry

[SP 345 934]

Potential GCR site

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Introduction

Judkins' Quarry has been proposed as a GCR site because it contains the largest and most comprehensive exposure anywhere in the Caldecote Volcanic Formation. The volcaniclastic lithologies exposed here (Figure 3.4) are more diverse than those seen at the formation's type section, in the Boon's Quarry GCR site, allowing a better appreciation of their mode of origin (e.g. Bridge *et al.,* 1998).

The site additionally represents the type locality for Precambrian intrusive activity in the Charnwood Terrane (Chapter 1), with all of the varieties discussed in the introduction to this chapter on view F. Jones, who realized that it was unconformably overlain by Lower Cambrian strata, discovered the largest of these intrusions in 1932. The intrusion was named 'granophyric diorite' by Wills and Shotton (1934), who compared it to the 'markfieldite' of Charnwood Forest (see the Cliffe Hill GCR site report, Chapter 2), thereby inferring for the first time the latter's Precambrian age. The chemical similarities between the Judkins' granophyric diorite and markfieldite were soon realized (Jones, 1935), and have been confirmed by recent studies utilizing both major and trace elements (Carney and Pharaoh, 1993; Bridge *et al.,* 1998). These correlations between the Nuneaton and Charnwood Forest basement sequences now have an added significance because the Judkins' granophyric diorite is the only representative of the Charnwood Terrane to have had its age determined precisely by the U-Pb zircon method. The age obtained, of 603 ± 2 Ma (Tucker and Pharaoh, 1991), is the minimum for deposition of the Caldecote Volcanic Formation, although its relevance to the age of the Charnian Supergroup in Chamwood Forest is challenged by palaeontological evidence, as discussed in the introduction to this chapter.

Many of the faults shown in (Figure 3.4) terminate at the base-Cambrian unconformity. The site is therefore of fundamental importance for unravelling the late Precambrian sequence of extrusion, intrusion and faulting in this sector of the Charnwood Terrane.

The Precambrian-Cambrian unconformity is a further major feature of this site, although it is unlike that at Boon's Quarry, being characterized by gullying and erosion rather than by weathering (e.g. Allen, 1968b; Bridge *et al.,* 1998). The site also exposes cross-sections through Trias-filled valleys eroded in the Precambrian surface.

Description

The site contains the two broad subdivisions of the Caldecote Volcanic Formation found in Boon's Quarry, to which the reader is referred for description. The crystal-lapilli tuff facies grouping forms most of the Precambrian exposure at the north-western end of the quarry (Figure 3.5) and is volumetrically the most important lithological division, amounting to about 85 per cent of the quarry exposures. Measured vertical sections through the Judkins' sequence shows that crystal-lapilli tuff can form massive beds up to 50 m thick.

Important sections showing the stratified top of a decimetres-thick crystal-lapilli tuff bed are displayed at Locality 1 (Figure 3.4). The lower stratified bed consists of lapilli tuff-breccia, about 12 m thick, characterized by about 25 per cent of dark grey to black porphyritic inclusions; some of these exhibit contorted or hooked shapes, and in certain layers they amalgamate to form discontinuous beds. The upper stratified bed, 10 m thick, is better-sorted and composed of centimetres-scale alternations between pale grey, coarse-grained crystal tuff and darker grey or greyish green crystal-vitric lapilli tuff. The latter is crammed with vitroclasts, 3 to 7 mm in size, with filamentous matrix textures, that enclose large quartz and plagioclase crystals with magmatically-embayed boundaries.

Large-scale disruption of bedding within the Caldecote Volcanic Formation is suggested by the sediment-raft breccias in the north-western part of Judkins' Quarry (e.g. Locality 2). These beds occur over at least 200 m of strike length; they contain metres-long rafts of laminated tuffaceous siltstone, some with ragged or feathered lateral terminations suggesting that they represent beds that were pulled apart within the enclosing tuff.

A further stratified variant of crystal-lapilli tuff is exposed beneath the Triassic unconformity in the central north-eastern face of Judkins' Quarry (Locality 3). It displays alternating crystal-dominant and lithic-dominant layers, and in thin section many of the lithic fragments are seen to be composed of devitrified and recrystallized volcanic glass, preserving relict perlitic textures. This lithology also encloses elongated, 10–40 mm size, dark maroon inclusions oriented parallel to local bedding planes; in a thin section they have fluidal textures resembling the fiamme of welded tuffs. Lower in the same section, beds of stratified and graded crystal-vitric tuff are apparently of basic composition; they contain abundant dark maroon, vesicular vitroclasts and fragments of dark brown, oxidized tachylyte glass, and there are no quartz crystals.

Representatives of the tuffaceous siltstone facies grouping occur at a few stratigraphical levels but are most prominent within a 7 m-thick series of beds, which can be followed for about 300 m along the north-eastern quarry face (e.g. at Locality 4). Descriptions of 'Bedded Tuffs' by Allen (1957), and of similar sequences by Lapworth (1886) and Wills and Shotton (1934), were based on earlier sections opened near here. The sequence locally contains green, laminated, fine-grained tuffs in beds up to 2 m thick. Thin sections show that these are vitric tuffs, crammed with devitrified glass shards showing sliver, crescentic, bubble-wall and Y-shapes. Accretionary lapilli, up to 4 mm in size, were found along a lamina plane in tuffaceous siltstone from the uppermost northern levels of Judkins' Quarry, as illustrated in Carney and Pharaoh (1993).

Basic intrusions occupy an estimated 15 per cent of the total Precambrian outcrop in Judkins' Quarry (Figure 3.4). They consist of fine-grained, porphyritic to sparsely-phyric basaltic-andesite and microdiorite sheets that invade many levels of the quarry and form bodies of variable thickness (2–50 m). They have mainly northerly or NNE orientations, which coincide closely with many of the faults truncated at the base-Cambrian unconformity. These intrusions, formerly known as the 'Blue Hole Intrusive Series' (Allen, 1957), are of similar field appearance and geochemistry (Carney and Pharaoh, 1993; Bridge *et al.,* 1998) to the North Charnwood Diorites of Charnwood Forest (Worssam and Old, 1988). Their Precambrian age is demonstrated, uniquely in the Midlands region, at the nearby Boon's Quarry GCR site.

The granophyric diorite body has a north-easterly trend, its margins in part fault-controlled, and it cuts across the mainly north-trending basic intrusions. It was this intrusion that yielded the 603 Ma radiometric age date discussed above. In appearance and geochemistry (Bridge *et al.,* 1998) it is identical to the South Charnwood Diorites of Charnwood Forest. Like the latter (see Cliffe Hill GCR site, Chapter 2), the diorite becomes finer grained towards its contact with the Caldecote Volcanic Formation, developing a dark grey, fine-grained porphyritic facies in which plagioclase euhedra (about 55 per cent) are accompanied by colourless clinopyroxene (20 per cent). Xenoliths form dark grey, fine-grained, angular inclusions in granophyric diorite from the north-western part of the intrusion (Locality 5). Although in hand-specimen they resemble certain of the basalt or basaltic-andesite intrusive rocks, their mineralogy is more appropriate to hornblende microdi-orite (Bridge *et al.,* 1998). A zone of darkened country rocks extending over several metres from the intrusive contact is attributed to thermal metamorphism by the diorite.

Near Locality 5, the upper surface of the granophyric diorite is sculpted into gullies infilled by pebbly and conglomeratic sandstone of the Lower Cambrian Hartshill Sandstone Formation, occurring on the next-highest quarry level.

Interpretation

The extensive sections in Judkins' Quarry expose a more complete record of variation within the Caldecote Volcanic Formation than seen in the Boon's Quarry GCR site, but generally support the interpretations already discussed. The role of contemporary pyroclastic activity in supplying fine-grade ash to the depositional basin is emphasized by the occurrence of vitric tuff beds up to 2 m thick, and by the observation of juvenile pyroclastic material (glass shards) admixed within the crystal-lapilli tuffs.

The stratified and graded tuff cappings to certain crystal-lapilli tuff beds are particularly reminiscent of subaqueous pyroclastic flows, as are the distinctive cracked and brecciated crystals (Fisher, 1984). Rapid emplacement of the flows caused instability and flowage within water-saturated, mechanically weak layers represented by the fine-grained sediments, resulting in contorted bedding and in places giving rise to sediment-raft breccias. Evidence for subaerial or phreatomagmatic eruptions, producing pyroclastic surges, is nevertheless provided by the single occurrence of accretionary lapilli and it may be speculated that this activity was linked also to the generation of subaqueous pyroclastic flows. According to Heinrichs (1984), accretionary lapilli can assume a protective outer coating and then be deposited subaqueously without disintegrating. Juvenile quartz, commonly with magmatically embayed boundaries, in association with plagioclase, indicates that the crystal-lapilli tuffs were the products of dacitic magmas. However, relatively thin intercalations of crystal-vitric tuffs that are quartz-poor also suggest contemporary basic or intermediate magma compositions.

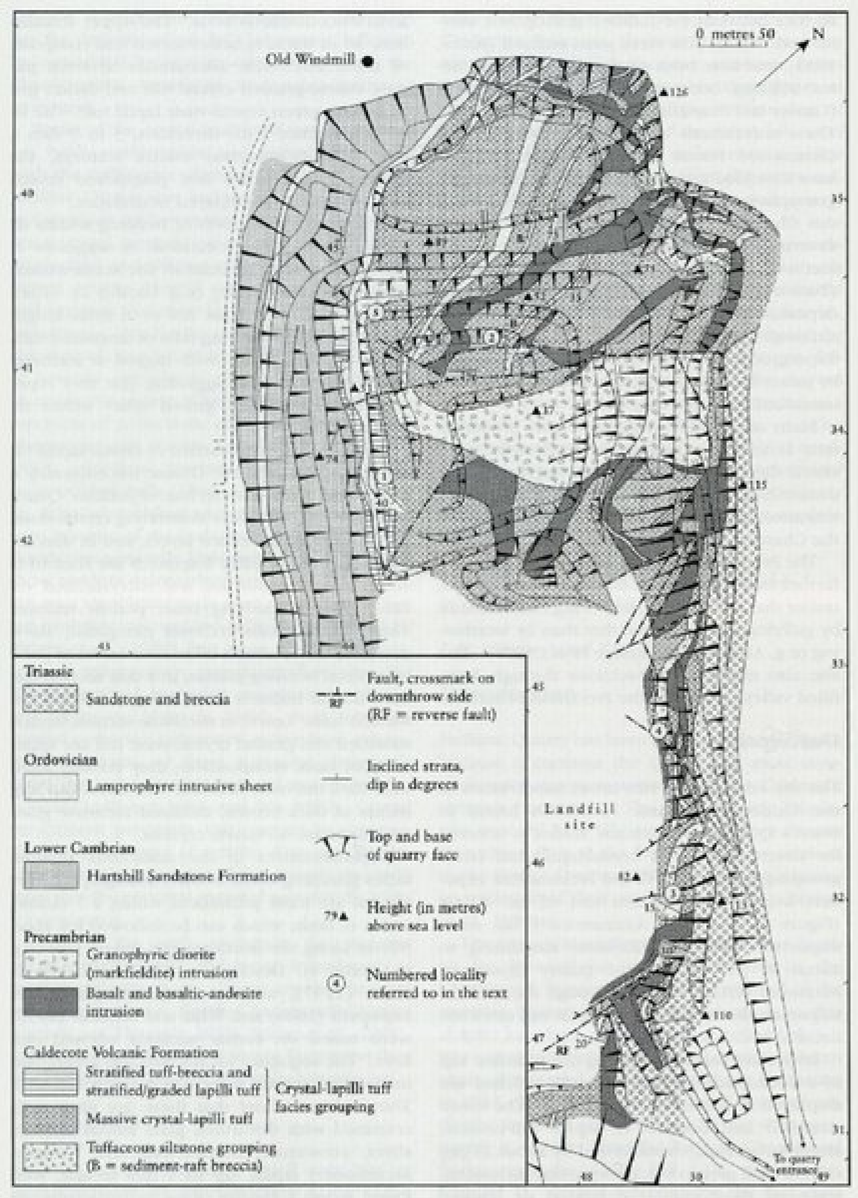
Later in the volcanic arc's evolution, magmas became more basic and were introduced as basaltic-andesite (microdiorite) sheets. The younger stock of granophyric diorite, geochemically correlated with the South Charnwood Diorites, represents a high-K calc-alkaline magma emplaced in an arc of increased maturity subsequent to further subduction-enrichment of the mantle source region (Pharaoh *et al.,* 1987b). Most intrusions were preferentially located either along or parallel to faults, demonstrating an important structural control on igneous activity; northerly faulting accompanied the first set of intrusions, but by the time the gra- nophyric diorite was emplaced, the stress regime had shifted and north-easterly faults were formed. Cessation of all magmatic activity, although not necessarily of tectonism, can be dated at, or soon after, 603 ± 2 Ma, the age of the granophyric diorite stock (Tucker and Pharaoh, 1991).

The unconformity with overlying Lower Cambrian marine sandstones is marked by a conglomerate resting on a gullied surface, which has been interpreted as a wave-cut platform (Allen, 1968b; Bridge *et al.,* 1998).

Conclusions

Judkins' Quarry contains the most extensive development of the Caldecote Volcanic Formation seen in the Nuneaton Inlier. It preserves complete cycles of sedimentation, a typical example commencing in dacitic crystal-lapilli tuff that remains massive over thicknesses of up to 50 m before passing up to a relatively thinner, stratified and graded upper part. This kind of variation has its parallel in young volcanic arcs elsewhere in the world and is attributed to the action of subaqueous pyroclastic flows carrying crystal-rich material derived from highly explosive eruptions. The flowage emplacement of these beds is underlined by phenomena indicating mass-instability of the sedimentary pile, such as the horizons of sediment-raft breccia and other soft sediment deformation structures occurring in association with the crystal-lapilli tuffs. The intervening finer-grained beds of tuffaceous siltstone contain accretionary lapilli and these, albeit rare in occurrence, testify to subaerial, or shallow water, pyroclastic activity in the volcanic source region(s). Explosive volcanic activity is typical of quartz phenocryst-rich, dacitic magmas, but the occurrence of quartz-poor tuffs also indicates the coexistence of andesitic or basaltic magmas within this arc system. The quarry exposures demonstrate a full sequence of Precambrian intrusion, post-dating the volcanism. Initially, basaltic to andesitic intrusions, chemically identical to the North Charnwood Diorites of Charnwood Forest, were intruded along northerly-trending faults. They were then cross-cut by north-easterly-trending faults, which in part controlled the margins of a granophyric diorite stock. The radiometric age of 603 Ma for this intrusion therefore constrains a time at which major changes in magmatism and tectonic style were occurring within the Charnian volcanic arc during the lead-up to its cessation. The fault-bounded Precambrian landmass was subsequently eroded, producing a locally irregular topography at the base of the overlying Lower Cambrian Hartshill Sandstone Formation.

References



(Figure 3.4) Geological map of Judkins' Quarry (from Bridge et al., 1998). The upper north-west levels of the quarry, below the 'Old Windmill', are recommended for conservation in the GCR.

(Figure 3.5) Quarry faces in Judkins' Quarry as at 1990, looking north-west. The west-sloping Precambrian—Cambrian unconformity is arrowed, with the Caldecote Volcanic Formation exposed on the right of it. (Photo: A14979, reproduced by kind permission of the Director, British Geological Survey, © NERC.)