CROFT HILL

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OS Grid Reference: SP510967

Introduction

The Croft Hill site exhibits coarse-grained plutonic rocks as small crags and pavements on the summit and flanks of the 123 m-high Croft Hill, and in the face of Croft Quarry, which is excavated into the SE side of the hill (Figure 5.2). These rocks have been studied petrographically over a long period of time; they were originally described as syenite (Hill and Bonney, 1878) before Whitehead (in Eastwood *et al*., 1923) suggested that, as no alkali feldspar is present, they should be classified as quartz-diorite or tonalite. The Croft pluton is now assigned to an assemblage of calc-alkaline intrusive rocks which, because of their geographical distribution, are collectively termed the 'South Leicestershire diorites' (Le Bas, 1968). These bodies are mostly hidden beneath Triassic strata, but have magnetic properties that enable them to be traced at depth as a series of small batholiths. The Croft Hill exposure is part of a composite pluton about 14 km wide, which is linked at depth with similar plutonic rocks cropping out around Stoney Stanton to the west and Enderby to the east (Allsop and Arthur, 1983).

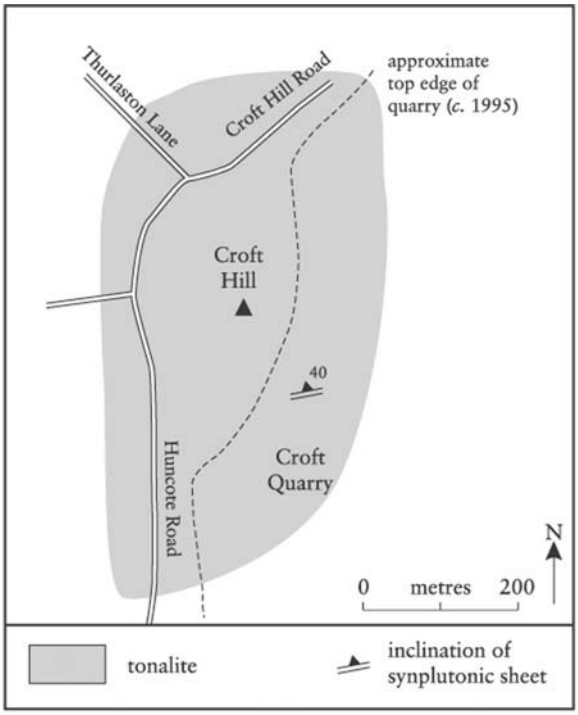

Figure 5.2: Map of the Croft Hill GCR site.

The significance of these rocks to the geology of central England is, in part, their age. A U-Pb date of 449 ± 18 Ma was obtained on zircon from the tonalitic rocks exposed at Enderby NE of Croft Hill (Pidgeon and Aftalion, 1978; recalculated by Noble *et al*., 1993), and is the currently accepted emplacement age of the South Leicestershire diorites. The plutons therefore belong to an Ordovician (late Caradoc) intrusive event, contemporaneous with the subduction-related magmatism of central Wales and the Lake District (Pharaoh *et al*., 1993). Their presence confirms that an extension of the Caledonian orogenic belt lies beneath much of central and eastern England (Le Bas, 1972; Pharaoh *et al*., 1987).

The Croft Hill site with its adjacent quarry offers extensive exposures demonstrating the petrology and internal intrusive history of a typical South Leicestershire pluton. It is also the location for an analcime-molybdenite style of mineralization, which is here more intensively

developed than elsewhere in the pluton.

Description

On the NW flank of Croft Hill small crags of inequigranular tonalite display abundant small white plagioclase phenocrysts set in a crumbly yellow or brown, medium-grained weathered base. At the summit, pavements of the same rock type are transected by an orthogonal fracture system, the principal trends of which are 360°, 260° and 240°.

Below the summit of Croft Hill, in the NW face of Croft Quarry (Figure5.3), is exposed massive, pale-grey, inequigranular medium- to coarse-grained tonalite. This is characterized by common large crystals of white euhedral plagioclase, up to 6 mm long, within a pink, medium-grained quartzo-feldspathic base studded with black oxide granules. The tonalite has a hypidiomorphic, inequigranular texture, with abundant euhedral plagioclase crystals, some with labradorite cores and rimmed by grainy, inclusion-filled albite. Surrounding these crystals are aggregates of smaller, inclusion-filled sodic plagioclase crystals which are in part idiomorphic and in part form an interlocking granular intergrowth with quartz. Clinopyroxene forms sporadic euhedra and aggregates largely altered to chloritic minerals; small tatters of biotite are similarly altered. Plagioclase is pervasively replaced by patches and veinlets of albite. Pumpellyite occurs interstitially, and Webb and Brown (1989) noted radial prehnite infilling cavities and zeolites occupying veins.

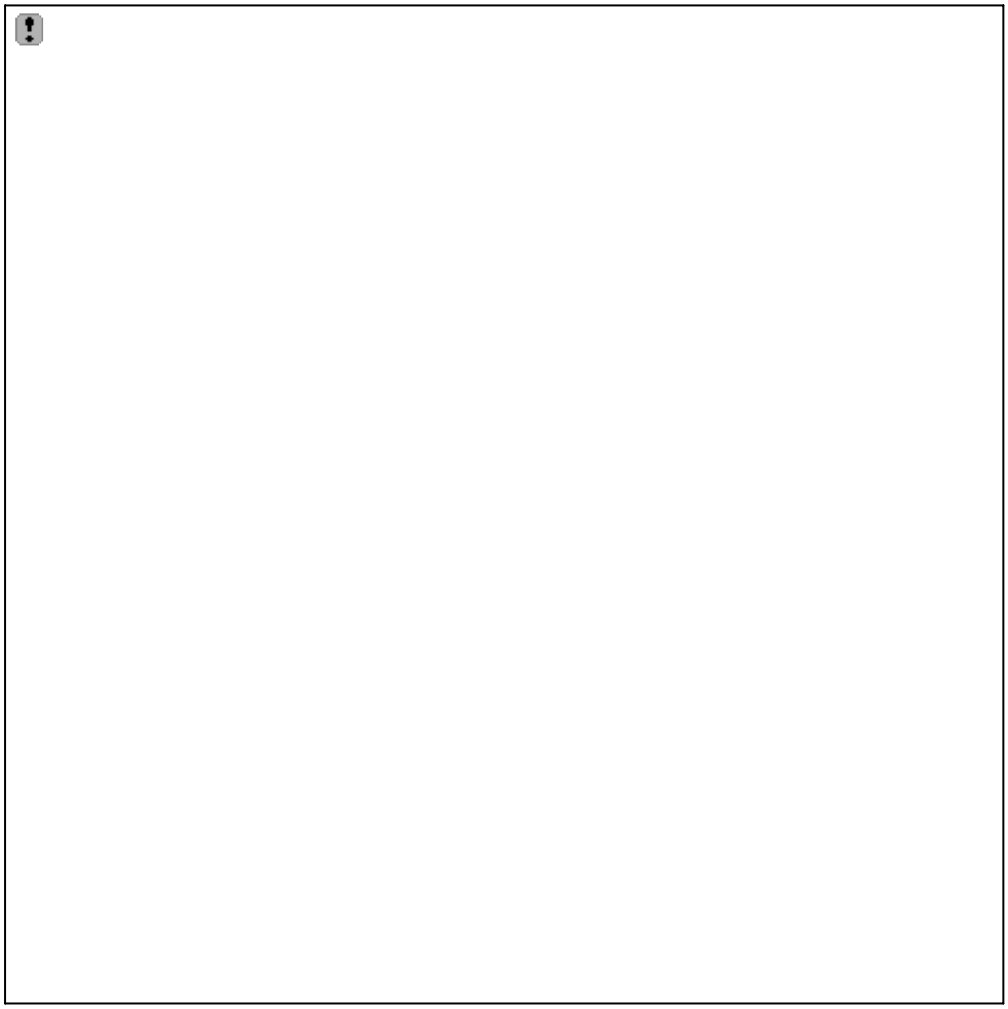

Figure 5.3: View of Croft Hill, showing the NW face of Croft Quarry. To the left of the picture, the dark-grey parallel lineaments dipping from top left to bottom right represent a swarm of synplutonic intrusive sheets. (Photo: J. N. Carney.)

A major feature of the intrusion occurs lower down in the same quarry face, where several sheets of darker-grey tonalite, 1 m to 3 m wide, extend up the face for tens of metres and

form a well-spaced 'swarm' dipping at about 40° to the NNW. The contact between these sheets and the host tonalite is sharp and irregular; slivers of the sheets are incorporated as xenoliths in the host. Neither the sheet nor the host is chilled, but the latter has intimately permeated the sheets as diffusely margined stringers of pale-grey tonalite which divide the sheet into rectangular to ovoid segments. The grey tonalite is mineralogically similar to the host, but is medium grained and non-porphyritic. Elsewhere in the quarry augite-bearing microdiorite xenoliths are common in the tonalite (Le Bas, 1968).

Prominent joint systems seen in the quarry below Croft Hill comprise a master set dipping 25° NNE and a subordinate set at right angles to this. In the SW quarry face, a prominent discontinuity outlines what appears to be a gentle dome-shaped structure, dividing intrusive rocks with different joint orientations. The nature of this structure cannot be determined as this part of the quarry is inaccessible.

The mineralization in Croft Quarry principally comprises the replacement of feldspar minerals by albite and analcime, producing the characteristic pink colour of the tonalites (King, 1968). The final stages of this alteration is known by local miners as 'rammel', which occurs in layers up to 12 m thick of completely disaggregated rock, commonly with cavities lined by crystals of analcime, calcite and quartz; prehnite, datolite, laumontite and dolomite are accessory minerals of this assemblage. The occurrence of minor amounts of molybdenite in this association is unusual because it normally belongs to a high-temperature environment, whereas analcime characterizes mesothermal and lower temperature environments (King, 1968).

Triassic strata mantle the southern part of the Croft tonalite and the highly irregular contact is well exposed just outside the limits of the site (Le Bas, 1993).

Interpretation

The rocks of Croft Hill constitute one of the few exposures of Caledonian igneous 'basement' in central England. Research during the 20th century has emphasized the unusual mode of occurrence of these rocks, as a pinnacle or inselberg buried beneath Triassic strata (Bosworth, 1912). Recent geophysical investigations have demonstrated that a much larger parent body is present at depth (Allsop and Arthur, 1983). Thus, the composition and variation seen within the Croft intrusion should be considered together with the very similar lithologies exposed at Stoney Stanton and Enderby, and encountered in the Countesthorpe borehole (Le Bas, 1972).

The Croft tonalitic intrusion is evidently part of a small, zoned batholith, with diorites to the west and microtonalite to the east (Le Bas, 1972). The Croft Quarry exposures suggest that even on a small scale, the batholith may have multiple phases of intrusion. The first phase comprised pale-grey inequigranular coarse-grained tonalite, which constitutes most of the northern face below Croft Hill. Parallel sheets of a darker-grey and more evenly grained tonalite were then emplaced into the main body, probably as a series of synplutonic intrusions because neither these sheets nor the host show chilling. Subsequent minor remobilization of the host resulted in brecciation of the synplutonic sheets. They were then extensively invaded by stringers emanating from the host, and in part stoped-out to form xenoliths within the latter.

The South Leicestershire diorites exhibit a strongly calc-alkaline geochemical signature (Le Bas, 1972; Webb and Brown, 1989). Pharaoh *et al*. (1993) noted that the Croft rocks show moderate enrichments of large-ion lithophile elements (K, Rb and Ba), Th and Ce, and relative depletion of Nb and Ta, which are patterns typical of calc-alkaline magmas arising within a volcanic arc founded on continental crust. The subduction zone above which the magmas were generated may have been situated to the east of central England in late Ordovician times, its activity related to the phase of plate convergence that closed the Tornquist Sea (Noble *et al*., 1993).

The widespread extent of albite and analcime replacement suggests pervasive deuteric alteration of the Croft rocks, a process possibly enhanced by the relatively complex emplacement history of the pluton evidenced by its zonation on a regional scale. The occurrence of molybdenite in association with these secondary minerals is unusual and not

understood fully.

Conclusions

The tonalites of the Croft Hill GCR site belong to the suite of late Ordovician intrusions known as the 'South Leicestershire diorites'. They represent one of the few exposures of the central zone of a small batholith, the larger part of which lies hidden beneath Triassic rocks. On a regional scale, the Croft body shows compositional zoning, indicative of a complex intrusive history. This is demonstrated at the smaller scale in Croft Quarry, where several parallel sheets of equigranular tonalite cut the host inequigranular coarse-grained tonalite, but were then brecciated and invaded during subsequent mobilization of the latter. Pervasive post-emplacement alteration of the tonalites involved the conversion of feldspar to albite, analcime and other zeolites, and was accompanied by minor molybdenite mineralization. The age and calc-alkaline geochemistry of the Croft rocks show that they were generated within a SE extension of the Caledonian magmatic belt and were contemporaneous with the volcanic and intrusive rocks of central Wales and the Lake District.

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