EXCURSION

Old Cliffe Hill and Whitwick quarries Charnwood Forest

Leader: John Carney (British Geological Survey)
Saturday, September 18th, 2004

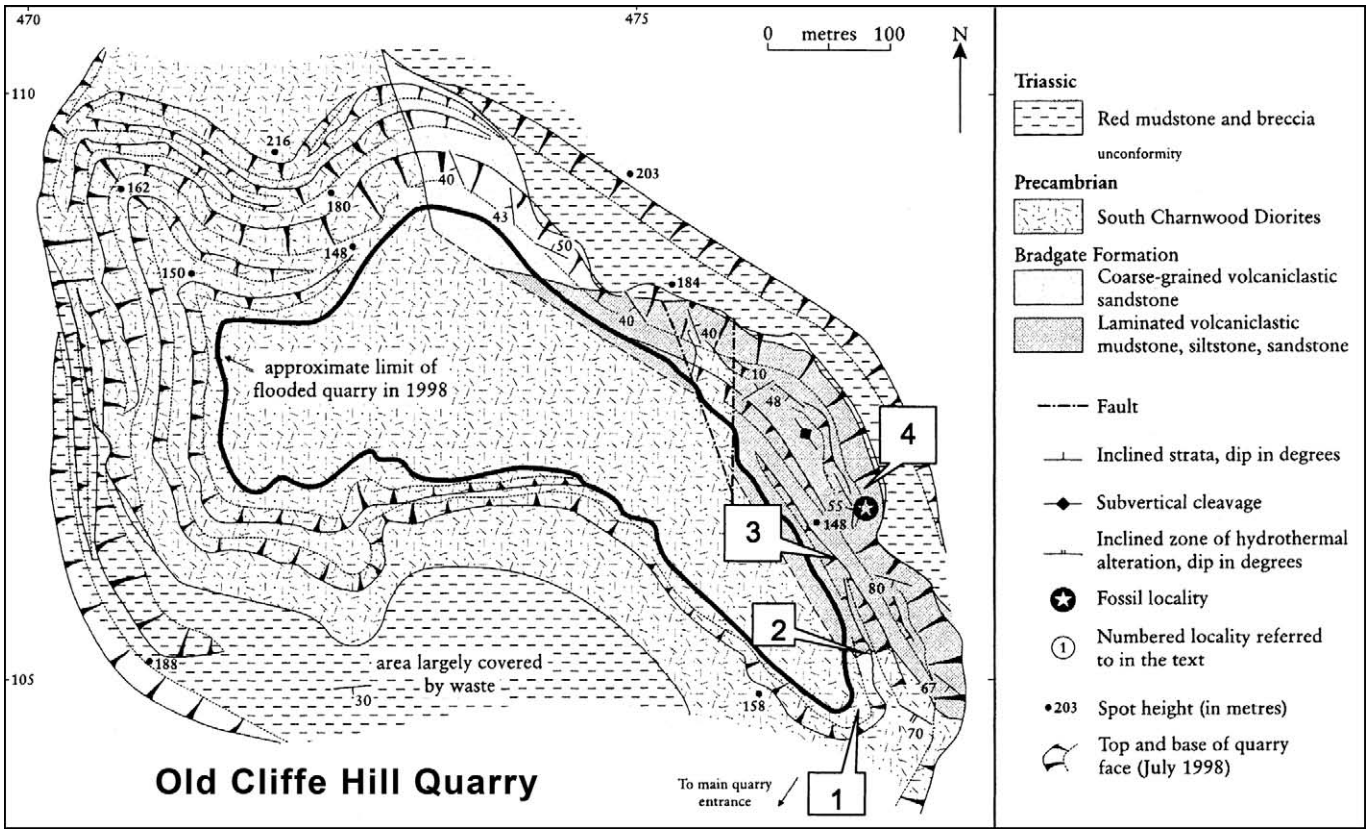
On a grey but fine Saturday morning the field party gathered at the offices of the New Cliffe Hill Quarry at the start of an excursion aimed at exploring two facets of Charnwood Forest's Precambrian geology. At the Old Cliffe Hill Quarry, rocks representing the very final intrusive stage of Precambrian magmatic activity are well displayed. By contrast, at Whitwick Quarry, a diverse assemblage of massive to fragmental igneous rocks is related to the earlier, extrusive phase of volcanic activity that was responsible for the accumulation of the volcano-sedimentary sequences forming the eastern outcrops of the Charnian Supergroup. Both quarries also offer sections through the highly irregular unconformity between Precambrian and Triassic rocks, and in particular they reveal the details of 'wadis', which are remnants of the Charnwood landscape as it existed about 240 million years ago. Safety regulations precluded the close examination of the higher quarry faces, but good examples of the range of lithologies abounded in the various piles of quarry waste, and were augmented by information obtained during previous visits by the excursion leader.

Old Cliffe Hill Quarry

After years of inactivity, this quarry (SK475106) was reopened in 2003 following the construction of a tunnel linking it with the main aggregate processing plant at New Cliffe Hill Quarry, 500 m to the west. This quarry is unique in that it clearly demonstrates relationships between volcaniclastic rocks of the Charnian Supergroup and a large intrusion of granophyric diorite. The intrusive rocks were named 'markfieldite' by Hatch (1909) after the quarried outcrops by Markfield village 1 km farther east, but in the Geological Survey Memoir (Worssam & Old, 1988) they are grouped within a unit called 'South Charnwood Diorites'. They are of great significance to regional Precambrian geology on account of their chemical and lithological similarities to an intrusion of granophyric diorite in Judkins Quarry at Nuneaton (Bridge *et al*., 1998). A correlation between the two intrusions has yet to be conclusively demonstrated, but would imply that the minimum age of the Charnian Supergroup and its fossils is 603 Ma, which is the U/Pb radiometric age of the Nuneaton diorite (Tucker & Pharaoh, 1991).

At Locality 1, fallen blocks of the South Charnwood Diorites examined by the field party revealed a remarkably homogeneous rock with a grey, coarsely mottled appearance on fresh surfaces. The components forming these mottles include about 30% of dark green-grey mafic minerals (mainly augite and chloritic alteration products) and a similar amount of pale grey plagioclase feldspar crystals, either as aggregates or as rectangular euhedra. The remainder consists of pink to grey-green, very fine-grained granophyre, which in thin sections consists of radiating, graphic-textured intergrowths of quartz and K-feldspar. These rocks are less sheared and have considerably larger amounts of granophyre than a further set of intrusions, the North Charnwood Diorites, which are probably slightly older. Chemical analyses (Worssam & Old, 1988) suggest a range of compositions including granodiorite, quartz diorite and monzodiorite, with quartz monzodiorite the commonest variety. Locality 2 could not be examined on the day, but is important for showing that the contact between the South Charnwood Diorites and Charnian Supergroup volcaniclastic rocks is intrusive, rather than being everywhere faulted as some have supposed. Here, the diorite darkens and fines progressively in grain size within about 10 m of the contact, indicative of chilling. It then develops a very fine-grained porphyritic selvage (resembling a volcaniclastic rock), about 1.5 m thick, immediately adjacent to the host rocks (Carney & Pharaoh, 2000). The latter are recrystallised to a pale cream, fine-grained lithology over several centimetres from the intrusion, and here Boulter and Yates (1987) found evidence for contact-related 'metasomatism' in the occurrence of mm-size, grey-green 'thermal' spots. These are restricted to certain sedimentary laminae, and in places have been slightly deformed by the regional Charnian cleavage. Evidence for a Precambrian folding event, prior to diorite intrusion, is suggested in this quarry by variations in the stratal dip of the Charnian Supergroup along parts of the northern intrusive contact. Such relationships could suggest that the strata were folded, either before or during their intrusion by the diorite.

At Locality 3 the party examined a fascinating diversity of sedimentary rock types and structures in blocks that had become detached from the nearby quarry faces. The strata exposed in this quarry are tentatively correlated with the Bradgate Formation of the Maplewell Group, and here they mainly consist of green to grey, parallel-laminated volcaniclastic siltstones and mudstones. Today, the fine rain that had fallen helped to show up fine-scale sedimentary structures, which included normal grading, contorted lamination, slump-folding, rafted lamination and syn-sedimentary microfaulting. On previous visits, fallen blocks were found containing single beds with highly contorted lamination sandwiched between undeformed strata. These may be seismites - beds that preserve deformation caused by an earthquake event. The northern part of the quarry was not visited, but it chiefly exposes amalgamated beds of graded, crystal-rich volcaniclastic sandstone, each about 4-5 m thick. The strata in this quarry show no evidence for storm-



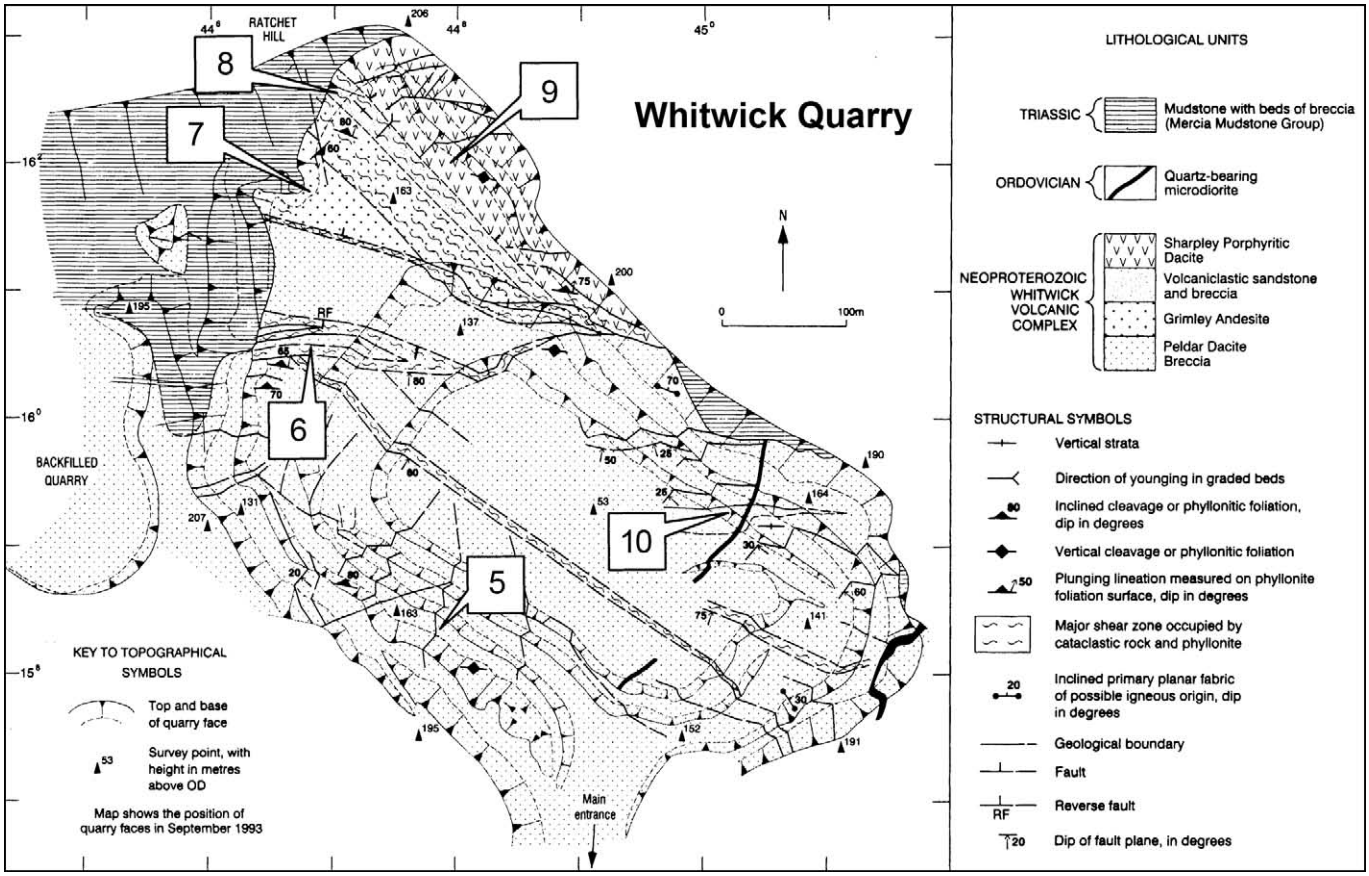
or wave-agitation and were therefore deposited at depths in excess of about 30 m. The common occurrence of normal grading indicates that the sedimentary particles were transported by flowage in turbidity currents, the overall environment being that of a deep marine basin marginal to a volcanic arc (Moseley & Ford, 1989; Carney, 1999).

Locality 4 contains one of Charnwood Forest's famous Precambrian fossil occurrences. It lies in part of the quarry conserved as an SSSI, but as this is situated on one of the higher and more inaccessible quarry faces it was not visited on the day. Here, a single bedding plane has yielded several discoid impressions, which Boynton (1978) first described and compared with the Precambrian fossil *Beltanella gilesi* Sprigg. Although the lack of internal detail raises doubts, Boynton & Ford (1995) later redefined these impressions and named one variety as *Cyclomedusa cliffi.* The other form recognised was *Cyclomedusa davidi*, which has no raised central boss.

Whitwick Quarry

The afternoon was taken up with a visit to this quarry (SK445158), which is currently disused. This is the type locality for the Whitwick Volcanic Complex (Carney, 2000), which consists of: *Peldar Dacite Breccia, Grimley Andesite* and *Sharpley Porphyritic Dacite,* all of these names following a nomenclature originally devised by Watts (1947).

The party first visited Locality 5, where blocks fallen from the quarry face showed details of a highly complex and little understood rock, the Peldar Dacite Breccia. Its most distinctive features are a dark grey to black appearance, abundance of large phenocrysts, and textures indicative of thorough brecciation (Carney, 2000). The rock is typically devoid of stratification, although other places in the quarry do show diffuse contacts between matrix-rich and matrix-poor breccia facies. This breccia is characterised by its numerous *porphyritic dacite fragments,* which vary in size from a few millimetres to over a metre. Although some are highly angular, many others have rounded to elliptical shapes, with incurved embayments and cuspate promontories reminiscent of pseudo-pillows. They have dark grey to black, fine-grained groundmasses enclosing large equant plagioclase phenocrysts and rounded phenocrysts of greenish grey quartz. The dacite groundmasses feature rounded, or rosette-like, microgranular clumps of strongly zoned quartz and feldspar. *Quartz microdiorite* fragments are medium-grained, pale green, and generally measure from a few millimetres to several centimetres in size (average about 50 mm). They are enclosed within both the breccia matrix and the porphyritic dacite fragments and commonly comprise a few per cent of the rock. In thin sections they mainly consist equant plagioclase crystals partly enclosed by quartz aggregates, the other constituents being interstitial albite, leucoxenized



oxide minerals, and chlorite-epidote alteration of original mafic minerals. The third component of this rock is the *matrix to the Peldar Dacite Breccia,* which is composed of crystal fragments and sliver-shaped volcanic grains, the latter possessing a fine-scale, spherulitic texture (Carney, 2000). Impressive specimens of the Peldar Dacite Breccia can also be examined in the walls of the nearby Mount St. Bernard Abbey (SK458163).

At Locality 6, the party examined parts of a major, bifurcating fault system that delimits the northern margin of the Peldar Dacite Breccia in the quarry. Individual zones of brecciated fault-rocks are tens of metres thick and some contain narrow, ductile shears in which the Peldar Dacite Breccia is recrystallised to a silvery-grey phyllonite – a type of fine-grained, foliated, tectonic rock mainly consisting of mica. In some ductile zones the foliation planes contain a faint mineral elongation lineation, which is defined by ellipsoidal areas of dark green-grey, chloritic material. The lineation invariably plunges down the foliation dip (northwards), and microfabric analysis (Carney, 1994) indicates that ductile movement was top-to-south, giving a reverse sense of throw for the fault complex. Argon isotope-series age dating of the micas (BGS, in progress) suggests that the ductile phase of fault movement was part of the Acadian (Siluro-Devonian) deformation event in southern Britain.

These fault zones were preferentially eroded in pre-Triassic times to form the wide palaeovalley, or 'wadi', intervening between localities 6 and 7 in the north-west of the quarry. Triassic red beds of the Mercia Mudstone Group subsequently filled the palaeovalley and here the party saw a fine example of a basal breccia composed of very local rock waste, perhaps a scree apron, derived from the valley sides. The breccia fragments are cemented by a matrix of pink, silty mudstone impregnated with veinlets and disseminations of calcite and possible barite. Beds of green-grey Triassic siltstone locally impregnated with malachite and with nodular masses of cuprite and tyrolite surrounding cores of native copper have also been found here (Carney *et al*., 2001). Such occurrences represent a classic 'unconformity-related' style of mineralization.

Grimley Andesite exposed at locality 7 is a grey-green, sparsely to moderately porphyritic, fine-grained lithology. Although appearing to be structureless, closer examination by the field party revealed that this rock has a shadowy breccia texture, similar to the Bardon Breccia seen farther south at Bardon Hill Quarry. The south-western margin of this exposure is strongly sheared over several metres, and has recrystallised to a silvery grey phyllonite. At Locality 8, the party saw that this margin of the Grimley Andesite is terminated by a subvertical screen, *c*. 30 m

wide, of strongly sheared volcaniclastic rocks. In many places the sedimentary rocks have been converted to phyllonite with a foliation trending north-west, parallel to bedding and to the local strike of the Charnian cleavage. The original volcaniclastic rocks appear to have consisted of andesitic breccia, porphyritic dacite breccia of 'Peldar' type and fine-grained, laminated, volcaniclastic sandstone and siltstone. There are also thin volcanic breccias with fragments of Sharpley Porphyritic Dacite, which are interleaved between graded, crystal-rich volcaniclastic sandstones and purple or maroon siltstone. The opposite contact of these sedimentary rocks, with the Sharpley Porphyritic Dacite, is sharp. However, Within a centimetre, the dacite phenocrysts become smaller and more scattered, and small flames and rafts of purplish grey siltstone appear within the dacite.

At locality 9, the last of the day, impressive exposures of Sharpley Porphyritic Dacite were examined. The phenocryst assemblage is similar to that of the Peldar Dacite Breccia, but this rock is devoid of brecciation. Its fine-grained, microcrystalline groundmass is grey to lavender on fresh surfaces, becoming pale grey when weathered. Locality 10 was not visited, but is significant in that it exposes a large raft of sedimentary rock, enclosed within the Peldar Dacite Breccia. The raft is composed of volcaniclastic siltstone with highly contorted and slumped lamination. Its contact with the Peldar Dacite Breccia is a complex zone of mixing, with coarse-grained lenticles of the crystal-rich breccia matrix visible in the siltstone, and rafts and wisps of maroon siltstone incorporated into the adjacent dacite breccia matrix (Carney, 2000).

The exposures available in Whitwick Quarry, while impressive, are not sufficient to provide a full understanding of what these rocks represent. When the surrounding outcrops in this part of Charnwood Forest are taken into account, however, a model can be suggested that views the Whitwick Complex as a concentration of massive to brecciated andesites and dacites that represent feeder bodies, and possible subvolcanic domes, emplaced into the Charnian volcanic axis. (Carney, 2000). In this model the Peldar Dacite Breccia, with its pervasive fragmentation, is interpreted as a peperite, which is a mixed rock formed by the brecciation of a magma upon its injection into wet sediments. The Grimley Andesite is probably the root-zone of an extrusive volcanic dome, which upon collapse contributed andesitic debris identical to the blocks that make up some volcanic breccias in the surrounding Charnwood Lodge Volcanic Formation. The Sharpley Porphyritic Dacite is an obvious source for similar pale grey dacite blocks found in volcanic breccias seen in the nearby exposures on Ratchet Hill. It may therefore be a further example of a high-level intrusion, perhaps a sill or a cryptodome, emplaced within an unconsolidated to partly consolidated sedimentary carapace.

Acknowledgements

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