EXCURSION

Day Excursion to the Cotswolds

Leaders: Mike Sumbler and Mark Barron, British Geological Survey, Keyworth, Nottinghamshire.

Sunday 16th July 1995

The purpose of the excursion was to visit two classic Cotswold localities, the first showing much of the Inferior Oolite succession, and the second a richly fossiliferous stratum in the Lower Lias.

After an uneventful drive from Nottingham, the first call was **Leckhampton Hill**, a promontory of the Cotswold Hills on the southern outskirts of Cheltenham. After disembarking from the coach at Daisy Bank Road, the party commenced the steep climb up an old tramway embankment leading to the long-abandoned quarries cut into the scarp face. In the Limekiln Quarry [SO 949 185], at the top of the tramway, the leaders explained the geological setting.

The quarries on Leckhampton Hill provide some of the finest exposures of the Inferior Oolite Group in the Cotswolds, with almost continuous exposure through a vertical succession of some 50m of beds (Fig. 1). Leckhampton lies within the so-called 'Cotswold Basin' of the literature (e.g. Arkell, 1933), which is better regarded as a shallow marine shelf sited to the west of a land area on the London Platform. During Triassic and Early Jurassic times, the area had indeed lain in a fault-bounded basin, the Worcester Basin, in which subsidence allowed nearly 2 kilometres of Trias and Early Jurassic sediments to accumulate. However, by the end of the Early Jurassic, about 178 million years ago, the basin was effectively full, and the bounding faults stabilised. Later subsidence was very minor by comparison, and could perhaps be accounted for in large part by compaction of the thick underlying sediment pile. In Mid Jurassic times, the site of the Worcester Basin became occupied by a shallow tropical sea, in which the majority of the sediments deposited were carbonates. A large proportion of this carbonate is in the form of rounded grains. These include true ooids (or ooliths) with a concentric internal structure, built up by accretion of carbonate around a nucleus. Other grains without obvious internal structure are known as peloids; these include faecal pellets and greatly abraded and altered detrital grains of shell material etc. The finer-grained carbonate matrix probably includes material of inorganic, faecal and algal origin.

The lowest strata exposed at Limekiln Quarry are the Scissum Beds, comprising 3 to 4m of rubbly, shelly, bioturbated sandy ferruginous limestones, weathering orange-brown. These formed in very shallow water. They rest with slight unconformity on the underlying Lias Group (not well seen at Leckhampton). Much of the terrigenous sand within the Scissum Beds probably represents reworked material from the Cotteswold Sands of the Upper Lias, originally derived from the London Platform. The Scissum Beds are fairly fossiliferous; members of the party collected a number of bivalves and brachiopods, a large belemnite, a possible coral and a poorly preserved, broken and completely septate ammonite, probably a *Leioceras*, the index genus for the early Aalenian.

Above, the Lower Limestone comprises about 3m of shell-detrital peloidal limestones, succeeded by the Pea Grit, about 4m thick. These beds stand out prominently in the face above the Scissum Beds, but neither is easily accessible. However, fallen debris enabled the party to examine the Pea Grit, which is packed with distinctive pisoids (or oncoids), ovoid layered grains up to 10mm or more in diameter. These pisoids are thought to have been formed by carbonate-secreting algae growing around a nucleus. The bulk of the enclosing sediment is fine-grained carbonate mud, implying a low-energy environment, and yet the growth of the pisoids implies a fairly high-energy regime, as they must have been flipped over periodically to allow uniform algal growth. Speculation on the palaeo-environmental implications of these features were cut short by the arrival of a *second* party of geologists, so our group moved on, up the steep path to the next site.

In the large Devil's Chimney Quarry [SO 946 184], the party admired the magnificent exposures of the Lower Freestone. This is the principal unit from which building stone was extracted; the material for many of the buildings of Cheltenham and surroundings originated here. The rocks are remarkably well-sorted, medium-grained ooidal limestones (grainstones). Cross-bedding on several scales indicates formation in a high-energy, current-swept environment, perhaps as shifting 'sand'-banks. Individual cross-sets within the Lower Freestone evidently accumulated very rapidly, perhaps in the course of hours rather than years. This is a reminder that, in shallow-water sedimentary successions such as the Inferior Oolite, the rocks preserved in a section represent only a very small part of the total span of geological time; more often than not, sediments deposited one day were swept away the next, and leave no trace in the sedimentary record.

A few individuals made their way along the face to examine the lower part of section, which contains some enigmatic trace fossils. These, typically subvertical tubes 1-2mm in diameter, in some cases branching at the base, have generally been recorded as rootlets in previous publications. However, from their general form, the total absence of associated carbonaceous plant material, and the nature of the sedimentary facies, it was generally agreed that they were burrows, probably made by some type of worm. They include forms similar to the ichnogenera *Skolithos* and *Lennea*. Such burrows are common in the lower part of the Lower Freestone throughout the region, and probably indicate extremely shallow-water conditions of deposition.

Above the Lower Freestone, the 'Oolite Marl' forms a paler band in the face. Most of the section is inaccessible, but those who clambered to the exposures saw a white carbonate mudstone, indicating a quiet-water environment in marked contrast to that of the Lower Freestone. It contains sporadic fossils including the brachiopod *Plectothyris*, with its distinctive wavy 'pie-crust' margin. It rests sharply on the Lower Freestone, which has a planar hardground top, showing worm and bivalve borings, and encrusting serpulid

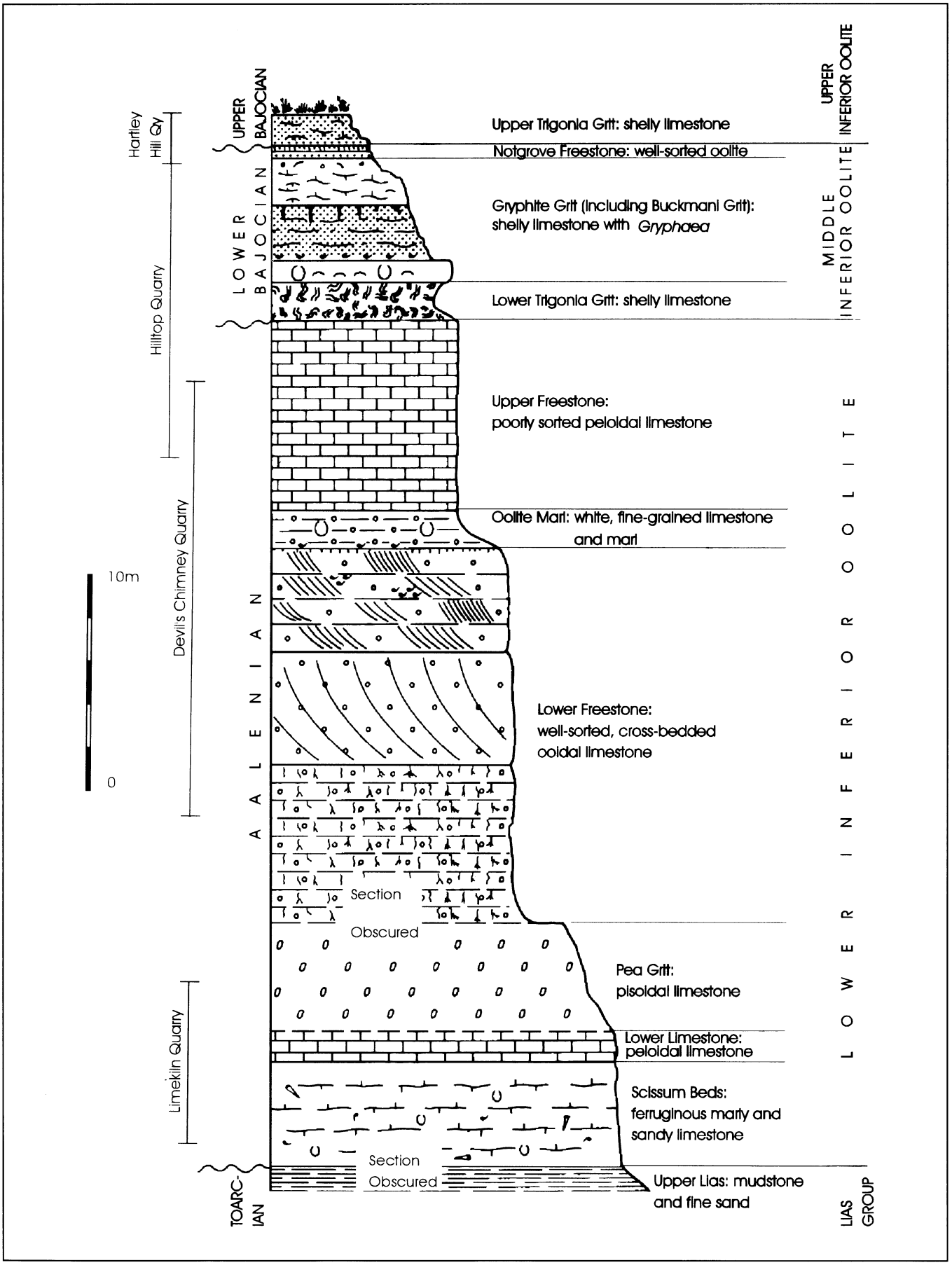

Fig. 1. Geological succession at Leckhampton Hill, based in part on Ager (1969). The vertical bars indicate the stratigraphical range of exposure in the four main quarries.

tubes and oysters. These features indicate a pause in sedimentation allowing stabilization and early cementation of the sea floor, before burial by Oolite Marl sediments.

As refreshment from purely geological matters, most of the party made the minor detour to look at, and photograph, the famous Devil's Chimney [SO 9664 1840], a pillar of rock left by quarrying. Local custom has it that young men used to climb it and jump to the cliff top, but none of the party could be persuaded to re-enact this feat! Recent attempts to stabilise the pillar are evident from the addition of masonry and rock-bolts.

At the top of the hill, the party gathered around the topograph to admire the fine views across Cheltenham and the Vale of Severn to the Malverns beyond. Curiously the topograph, which lists the prominent landmarks, is seriously misaligned, resulting in some confusion for users! In fact the errors are not consistent, suggesting that the topograph was originally destined for some other site a little farther along the hill.

The prominent cliffs along the Cotswold edge had prompted early geologists to suggest that the scarp was a 'fossil' sea-cliff, formed during an episode of high sea-level during Pleistocene times (e.g. Buckman, 1849; Hull, 1857). Though an appealing idea, this is now known to be false, and the scarp-edge (formed of Inferior Oolite limestones), and the Vale of Severn below (floored by Lias mudstones), are entirely the result of terrestrial erosion processes. During the cold phases of the Pleistocene, these processes would have been greatly accelerated. The area would have been barren of vegetation, and weathered material that accumulated during the icy winters would have formed a slurry during the summer thaws, which gradually flowed downslope to be swept away by swollen streams and rivers. Landslipping of the Lias would have led to rapid retreat of the scarp. The process of landslipping continues to the present day, albeit on a reduced scale, as witness the distinctive hummocky appearance of the Lias slopes below the scarp edge.

This speculation over landscape development led to a discussion over drainage history: prior to the Anglian glaciation, it was claimed, the River Severn had flowed not in its present Vale, but to the west of the Malverns, and the site of the present Vale was then an interfluve. This was countered by the statement that the distribution of tills and other drift deposits show that an embryonic Vale of Severn had existed as a low-lying area during much of the Pleistocene. In fact, there have been such great changes in river systems during the Pleistocene that it is a moot point whether it is appropriate to use the name 'Severn' for either river, west or east of the Malverns, when talking about a situation that pertained half a million years ago.

Passing over the iron-age hill-fort on the summit of Leckhampton Hill, the party arrived at Hilltop Quarry [SO 9499 1850]. The more intrepid made their way down to the main face, where the Upper Freestone was visible. Though superficially similar to the Lower Freestone, close examination with a lens reveals that the Upper Freestone is a peloidal limestone, with a fine-grained matrix (packstone), indicating that it was formed in a substantially lower-energy environment. Above, a thin lens of brown *marl* probably represents the lower part of the so-called Harford *Sands*; nomenclatorial anomalies such as this are just one reason why the BGS has introduced a new scheme of nomenclature for the internal subdivisions of the Inferior Oolite Group of the Cotswolds, details of which will be published elsewhere. Resting on these marls, the Lower Trigonia Grit was seen. This, the basal unit of the Middle Inferior Oolite, is a grey to brown, slightly sandy, rubbly or massive limestone rich in shell debris; it is crowded with 'ropes' of tiny serpulid tubes (*Sarcinella*), which are generally common at this level. The Lower Trigonia Grit is generally similar to the other 'grits' of the Middle Inferior Oolite, but is characterised by brown, ferruginous peloids, giving an 'ironshot' appearance.

The Gryphite Grit is exposed in the upper face of Hilltop Quarry, and is characterised by an abundance of *Gryphaea bilobata* J de C Sowerby in its upper part. Some members of the party paused to collect specimens of these oyster-like bivalves, though others were more taken by another large mollusc, *Helix pomatia* Linneaus, the Roman or Edible Snail, which was quietly browsing the vegetation. These impressive gastropods are not rare in the Cotswolds, but are very local in their distribution, being confined to areas around former Roman settlements, where they were cultivated for the table. Even in the 1500 years or so since the Romans left Britain, the snails have not advanced very far into the surrounding countryside.

Passing through the gate off the Common, the path follows the margin of the shallow but extensive Hartley Hill Quarry. The floor of the quarry has been restored to agriculture; at the time of our visit, a fine crop of borage was in full flower. The purpose of this crop was a source of puzzlement to most members of the party, but we have subsequently discovered that its seeds are rich in gamma linoleic acid (or 'GLA'), also found in other plants such as Evening Primrose. GLA, which fetches a high price, is used in pharmaceuticals and tonics.

Above the Gryphite Grit, the succeeding Notgrove Freestone and basal Upper Inferior Oolite were seen in the low face of the quarry adjacent to the path [SO 9523 1846]. The Notgrove Freestone is lithologically similar to the Lower Freestone and likewise has a hardground at the top. This hardground is particularly well-developed, and is characterised by abundant and deeply penetrating worm borings. It marks an important erosive non-sequence. Traced eastwards from Leckhampton, the erosion surface cuts progressively through older parts of the Inferior Oolite until, in the Bourton-on-the-Water area, the hardground is developed upon the Scissum Beds. This relationship probably resulted from gentle flexuring caused by a minor renewal of movement at the boundaries of the buried Worcester Basin, followed by submarine planation. The succeeding Upper Inferior Oolite thus rests discordantly on the underlying beds. The basal unit, the Upper Trigonia Grit, is a shelly limestone similar to the 'grits' of the Middle Inferior Oolite. It yielded a number of fossils, mostly preserved as empty moulds, including the eponymous *Trigonia costata* Parkinson.

The party returned to the waiting coach and travelled the short distance to Andoversford, where lunch was taken at the Frog Mill Inn [SP 027 183].

After lunch, the party were driven via Bourton-on-the-Water, Stow-on-the-Wold and Moreton-in-Marsh to **Blockley Brickworks** [SP 181 370]. Operated by Northcot Brick Ltd, it is one of the few remaining brickpits to exploit the Lower Lias. It is sited in the low ground below the Cotswold scarp, at a horizon equivalent to a level about 150m below the base of the Inferior Oolite at Leckhampton. The party entered the pit via the works yard, where the finished bricks were seen. Although all are manufactured from the same raw material, a number of different colours are made by using a dressing of sand mixed with metal oxides, that develops the required colour on firing.

The pit exposes about 18m of strata, comprising bluish grey mudstones with limestone and siderite nodules (Fig. 2). The uppermost beds are somewhat silty, heralding the upward passage into the overlying Dyrham Siltstone Formation, the base of which lies some 20 or 30 metres stratigraphically above the top of the section. The ammonite fauna of the beds, for which the pit is famous, indicates that the strata belong to the *Beaniceras luridum* Subzone of the *Tragophylloceras ibex* Zone (Lower Pliensbachian). The most fossiliferous part of the section is the Pecten Bed, about midway up the pit face. Because of the abundance of fossils, the Pecten Bed is rich in lime and so is discarded by the brick-makers; a huge amount of this fossiliferous waste material is piled up on the eastern side of the pit.

Regrettably, fossils proved to be less abundant than they had been earlier in the year, when a large area of the Pecten Bed had been newly stripped of its overburden. The pit also suffers from the predatory attentions of professional fossil dealers. Nevertheless, most of the party managed to collect some attractive specimens, either from *in situ* or from the waste dumps. The Pecten Bed yielded numerous bivalves including

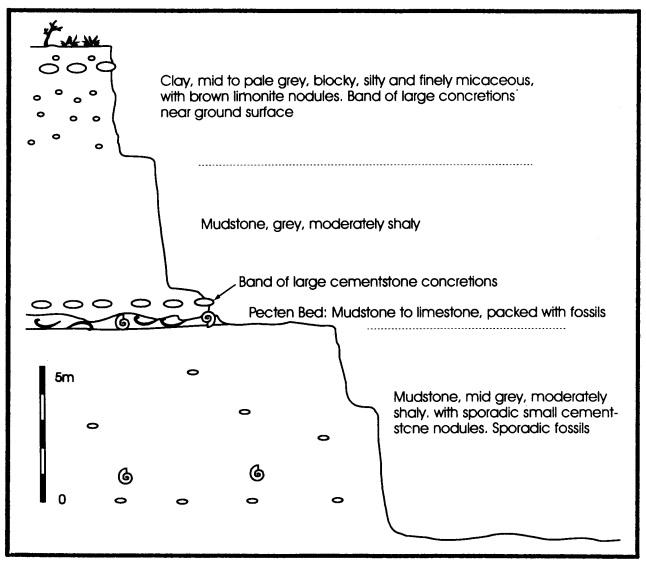

Fig. 2. Geological succession at Blockley Brickworks, July 1995. The section lies within the *Beaniceras luridum* Subzone of the *Tragophylloceras ibex* Zone (Lower Pleinsbachian). Additional information is given by Callomon (1968) and Phelps (1985).

Pseudopecten equivalve J Sowerby (the 'Pecten' after which the bed is named), as well as gastropods and belemnites. Ammonites were also found. These included representatives of the three main subdivisions of the Order Ammonoidea, namely the Phylloceratina, represented by *Tragophylloceras loscombi* (J Sowerby), the Lytoceratina, represented by *Lytoceras fimbriatum* (J Sowerby) and the Ammonitina (the true ammonites), represented by members of the family Liparoceratidae. The liparoceratids have been the subject of much taxonomic debate, and various generic and subgeneric names (e.g. *Aegoceras*, *Androgynoceras*, *Beaniceras*, *Liparoceras*) have been applied to them in varying combinations. This has been prompted by the recognition of three morphological types: large, inflated sphaerocones, with a double row of tubercles on the whorl side (typical *Liparoceras*); small to medium-sized, evolute serpenticones with strong widely-spaced ribs (the so-called capricorns); forms showing both these ribbing styles (variocostates). Some authors consider that the three types represent an evolutionary sequence, either from capricorn to typical *Liparoceras*, or vice versa, but others regard them as a manifestation of sexual dimorphism. Most recently Phelps (1985), who studied the ammonite biostratigraphy at this stratigraphical level throughout northwest Europe, considered the variocostates to be rare, extreme morphological variants of capricorn species.

A heavy shower whilst collecting dampened spirits, and as time was short, the party returned to the coach. After a vote of thanks for the leaders, the party set off back to Nottingham.

Acknowledgements

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M. G. Sumbler and A. J. M. Barron
British Geological Survey
Keyworth
Nottingham NG12 5GG