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Geological notes and local details for 1:10 000 Sheet SP 11 NW (Farmington)

Part of 1:50,000 Sheets 217 (Moreton-in-Marsh) and 235 (Cirencester)

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-= C O N T E N T S =-

1 INTRODUCTION

This account describes the geology of 1:10 000 Sheet SP 11 NW (Farmington). The area falls largely within 1:50 000 Geological Sheet 235 (Cirencester), although the northenmost srtip (about 100m wide) forms part of Sheet 217 (Moreton-in-Marsh).

The first geological survey of the area was undertaken by E Hull during the 1850s; it was published as part of Old Series One-Inch Geological Sheet 44 in 1856, and described by Hull (1857). This survey was re-issued with minor amendments as New Series One-Inch Geological Sheets 217 and 235, published in 1929 and 1933, respectively. For the Farmington area, the only change from Hull's original survey was the addition of alluvium and some outcrops of Chipping Norton Limestone by H G Dines. The geology of sheets 217 and 235 is described in memoirs by Richardson (1929; 1933); these are based on the work of Hull, supplemented by additional data such as quarry sections.

The Farmington area was surveyed at the 1:10 000-scale by M G Sumbler during 1993-4, as part of the resurvey of Sheet 235 (due for completion in 1995). This report is based mainly on this latest work, but also incorporates data from Richardson (1933) and other sources where appropriate. Certain biostratigraphical information in this account is taken from reports by Cox (1994a, b) and Ivimey-Cook (1993; 1994). Measured sections from the lettered localities indicated on the map are given in Appendix 1.

The area lies in the heart of the Cotswolds, between Northleach and Bourton-on-the-Water, on the Roman Foss Way (the A429) which connects Cirencester and Stow-on-the-Wold. The A40 Oxford-Cheltenham trunk road crosses the south-western corner of the area. Away from these two major roads, the area has a peaceful, rural character, and the three villages, Farmington, Cold Aston (also known as Aston Blank) and Turkdean are seldom visited by tourists. Much of the area comprises open plateau, used chiefly for arable farming. This plateau is dissected by a number of narrow, steep-sided valleys, given over to pastureland, used for sheep and cattle, with some woodland. The main valleys contain intermittent streams which enter the more or less perennial Sherborne Brook (a tributary of the River Windrush), which runs through the principal valley between Turkdean and Farmington. The River Leach crosses the south-western corner of the area; it is a small stream which rises from springs immediately to the west.

Apart from small areas of Lias in the valley-bottoms, the 'solid' rocks which crop out in the Farmington area belong to the Inferior and Great Oolite groups, of Mid Jurassic age. The plateau which dominates the topography is formed chiefly by limestones of the Great Oolite Group. The mudstones of the Fuller's Earth Formation at its base, and the limestones of the underlying Inferior Oolite Group, typically crop out in the valley sides. Drift deposits have a very limited extent, being restricted to alluvium and head deposits in the valleys, together with landslip deposits derived mainly from the Fuller's Earth Formation.

This report is best read in conjunction with 1:10 000 Geological Sheet SP 11 NW. This map indicates the outcrop limits of deposits which are mostly concealed beneath soil and vegetation; the geological boundary lines are inferred from indirect evidence such as the form of the ground surface and soil type, or are extrapolated from adjoining ground. The map is thus the subjective interpretation of the surveyor, and all geological boundaries carry an element of uncertainty. Boundaries of solid geological formations which (in the opinion of the surveyor) can be located to within about 20m on the ground, are shown as unbroken lines on the map; all others are shown broken.

Dyeline copies of the 1:10 000 map can be purchased from BGS, Keyworth, where records of boreholes may also be consulted. Equivalent maps and reports covering the adjoining sheets to the west, south and east are available or are in preparation.

National Grid References are given in square brackets throughout; all lie within 100km grid square SP (or 42).

QUATERNARY:	
LANDSLIP	
HEAD	up to c. 3
ALLUVIUM	up to c. 2
RIVER TERRACE DEPOSITS	up to c. 3
MIDDLE JURASSIC:	
GREAT OOLITE GROUP:	
White Limestone Formation	6+
Hampen Formation	6 to 8
Taynton Limestone Formation	7 to 11
Fuller's Earth Formation	12 to 15
Chiping Norton Limestone Formation	0 to 2
INFERIOR OOLITE GROUP 25 to 60 including:	
Salperton Limestone Formation:	
Clypeus Grit Member	10 to 15
Upper Trigonia Grit	0 to ?1.2
Aston Limestone Formation	0 to 5
Birdlip Limestone Formation:	
Harford Member	0 to ?0.5
Scottsquar Hill Member	0 to 10
Cleeve Cloud Member	10 to 30
Leckhampton Member	3 to 10
LOWER JURASSIC	
LIAS GROUP:	
Upper Lias	40+

Table 1. Geological sequence proved within Sheet SP 11 NW (Farmington), giving approximate thickness in metres. Nomenclature for the Inferior Oolite and Lias groups is provisional.

2 LOWER JURASSIC: LIAS GROUP

2.1 UPPER LIAS

The total thickness of the Upper Lias in the area is uncertain, but information from adjoining areas suggests that it thins eastwards, reflecting its position on the eastern margin of the buried Triassic-Jurassic Worcester Basin. The basin margin, against the Palaeozoic massif of the London Platform, had an important influence on Mesozoic sedimentation; it is generally regarded as an axis of relative uplift (the so-called Vale of Moreton Axis). The Upper Lias may be about 90m thick in the west (by reference to the Stowell Park Borehole [0835 1176] on Sheet SP 01 SE; Green and Melville, 1956), but is perhaps only 50m or less in the east (as at outcrop on Sheet SP 11 NE). The formation is dominated by grey mudstones; Borehole 4 [1064 1719], sited on the valley floor at Turkdean, proved 'blue clay' with some thin bands of 'blue stone' to a depth of 38.71m; all is assigned to the Upper Lias.

Only the uppermost few metres of the Upper Lias is represented at outcrop in the area. Springs issuing from the base of the Inferior Oolite on the banks of the Sherborne Brook on the eastern margin of the area [150 152] suggest the presence of Upper Lias mudstone in the valley bottom there. Up to about 5m of strata are represented in the valley bottom north-east of Starvall Farm [144 164]. The outcrop is asymmetric with respect to the valley, being present on the convex spurs [148 169; 148 165] but not on the opposite slope of the valley; this is the result of valley bulging (see Structure). A similar effect is apparent in the valley bottom at Turkdean [101 175 to 108 171].

The beds at outcrop comprise grey mudstones, which weather to a brown clay. The soil is commonly somewhat sandy or silty, but this probably results largely from downwashed material fron the overlying Leckhampton Member (Inferior Oolite Group); the mudstones themselves are not generally sandy, although they may include thin beds of silty mudstone, and may be slightly, finely micaceous in the topmost part. There is no compelling evidence for Cotteswold Sand at the top of the Upper Lias in this area; it is probably overstepped by the Inferior Oolite some distance to the west, being absent even in the Stowell Park Borehole (*recte* Green and Melville., 1956). The 4.6m of 'grey sand' recorded above 'blue clay' of the Upper Lias in Borehole 3 [1179 1648] at Leygore Manor is somewhat suggestive of Cotteswold Sand, but given the regional evidence, is more likely to belong to the Leckhampton Member.

3 MIDDLE JURASSIC: INFERIOR OOLITE GROUP

The Inferior Oolite Group is divided into three formations, the Birdlip Limestone, Aston Limestone and Salperton Limestone formations, in ascending order. These newly named formations correspond respectively with the traditional subdivisions (subgroups) of Lower, Middle and Upper Inferior Oolite.

Only Borehole 3 [1179 1648] at Leygore Manor, penetrated the whole of the Inferior Oolite, proving a total thickness of 59.44m. Borehole 5 [1119 1953] to the north, probably proved about 60m, without bottoming the limestones, and boreholes 6 [1241 1991] and 13 [1282 1971] at Cold Aston probably proved in excess of 60m (not bottomed). At Turkdean, in the west of the area, the total thickness estimated from outcrop is only about 40m, but this apparent thinning is probably largely a result of valley bulging, which brings the Upper Lias to a higher level along the valleys here (see Structure). There is some evidence of thinning to the south, however, with only c. 45m present at Northleach (Sumbler, 1994b).

As with the Upper Lias, the Inferior Oolite Group shows a very pronounced thinning from west to east, with only about 25 to 35m present along the eastern boundary of the area; this figure is supported by evidence from adjacent areas, and takes account of the effect of valley bulging. The thinning is almost entirely concentrated within the lower part of the group (the Birdlip Limestone and Aston Limestone formations). It is the result of condensation combined with the progressive overstep of component members beneath erosion surfaces at several horizons.

3.1 BIRDLIP LIMESTONE FORMATION: LECKHAMPTON MEMBER

The Leckhampton Member (formerly Scissum Beds) comprises grey to orange brown, ferruginous very sandy, fine grained ooidal limestone, commonly with scattered shell fragments, and occasional moulds of fossils, mainly bivalves. It is typically has a rather rubbly character, probably due to intense burrowing. At outcrop, it is generally more or less decalcified to a yellowish brown sand or loam, often containing lumps of less decalcified limestone. Despite obscuration by valley wash, the outcrop is generally easy to find, as the sands are often sought out by burrowing animals such as badgers and rabbits.

Within the Farmington area, the outcrop of the Leckhampton Member is restricted to the bottom of the valley of the Sherborne Brook, in which it appears near Turkdean [100 175 to 124 174], and sporadically to the east. Its presence or absence in the valley floor is in part dependent on localised valley bulging, which also accounts for the notably asymmetric outcrop in many places (see Structure). The thickness is estimated to be about 10m near Turkdean, thinning to only 3 to 5m in the east. The Leckhampton Member is probably represented by 4.3m of 'red sand' overlying 4.6m of 'grey sand' at the base of the Inferior Oolite in Borehole 3 [1179 1648]. Small exposures of the member were seen at localities H [1180 1706] and N [1316 1749 to 1324 1748] (Appendix 1).

3.2 BIRDLIP LIMESTONE FORMATION: CLEEVE CLOUD MEMBER

The Cleeve Cloud Member corresponds with the Lower Freestone of previous accounts. Within the Farmington area, it rests directly on the Leckhampton Member. To the west, the Crickley Member (formerly Lower Limestone and Pea Grit) intervenes between the Cleeve Cloud and Leckhampton members. As there appears to be a vertical passage between the Leckhampton and Cleeve Cloud members (at least in the western part of the Farmington area; see below), it seems likely that the absence of the Crickley Member is due to a lateral passage into the lower part of the Cleeve Cloud Member.

Hull (1857, p.40) reckoned the Cleeve Cloud Member ('Freestone') to be 14.0m thick at Turkdean in the west of the area, but although this accords approximately with the mapped outcrop there, it is probably a considerable underestimate because of valley bulging. Given a total Inferior Oolite thickness of some 60m (see above) the true stratigraphic thickness of the member is probably about 30m to 35m. Eastwards, the Cleeve Cloud Member thins dramatically, being generally about 15 to 20m thick in the eastern part of the area, and in the south-eastern corner, only 10m or less.

The Cleeve Cloud Member crops out on steep lower slopes of the valleys of the area. Typically, it is a thinly bedded, very well-sorted, fine to medium grained, compact ooid grainstone, which forms a brash of platy fragments. Coarser-grained beds also occur, and in some cases these contain a certain amount of shell debris. It is generally white to pale yellowish brown in colour, but some layers are stained strongly yellow, orange or brown with limonite, which contrasts with the paler ooids. These yellowish, ferruginous limestones dominate the thinner, eastern succession, and comprise the 'Yellow Stone' of Richardson (1933; see below). Generally, the ooids appear to have quartz sand nuclei, and some beds are very sandy, particularly in the lower part of the succession; locally these sandy beds decalcify to a sandy loam like that associated with the Leckhampton Member; the similarity of facies suggests a vertical passage between the two members (but see below). Fossils are generally rare, but some bedding planes are crowded with the small pectinid bivalve *Propeamussium.*

The thin eastern development of the Cleeve Cloud Member was termed the 'Yellow Stone' by Richardson (1933, p. 15; see Appendix 1, Locality Q). He equated these beds with the 'Pea Grit Series' (Crickley Member) (see also Richardson, 1904a, b), but given the relationship suggested above, the Yellow Stone, and its probable equivalent in the Moreton-in-Marsh District, the Yellow Guiting Stone (or Jackdaw Quarry Oolite; Mudge, 1978), probably represent the combined Crickley and Cleeve Cloud members. However, the local development of the Yellow Stone is closely similar in lithology to the Cleeve Cloud Member of the Stowell Park Borehole [0835 1176] (as now classified), which there overlies a well-developed Crickley Member. This suggests the possibility that the strata equivalent to the Crickley Member are absent in the east of the Farmington area, implying a non-sequence between the Cleeve Cloud and Leckhampton members there.

The overlying Scottsquar Hill Member rests sharply and non-sequentially on the Cleeve Cloud Member. In the eastern half of the area, the top surface of the Cleeve Cloud Member is commonly developed as a hardground, often showing borings and encrusting oysters and serpulids. More locally [e.g. 1490 1666; 1470 1789] it shows signs of decalcification, and solution, and is strongly stained with limonite. It has the appearance of palaeokarst, suggesting subaerial emergence, although the effect may alternatively be due to recent weathering, perhaps related to a former groundwater level.

The Cleeve Cloud Member was exposed at localities D, N, O, Q, X and Y (Appendix 1). The best section still visible is Turkdean Quarry (Locality D [1084 1711]), which shows the uppermost 5m of the member, comprising massive ooid grainstones with a planed top.

3.3 BIRDLIP LIMESTONE FORMATION: SCOTTSQUAR HILL MEMBER

The Scottsquar Hill Member constitutes the Upper Freestone and Oolite Marl of previous accounts. It reaches a maximum of perhaps 10m in thickness in the northern and western parts of the area, but is generally thinner (c. 5m). It is absent altogether in the south-east [148 153], due to overstep by the Clypeus Grit (Salperton Limestone Formation). It also appears to be absent in the valley of the Sherborne Brook near Farmington [124 160; 140 157]; in this area, the Clypeus Grit rests directly on the Cleeve Cloud Member, as in the south-east.

The Scottsquar Hill Member is dominated by white to grey or brown, medium to coarse-grained peloid and ooid packstone to grainstone (Upper Freestone facies). It is typically rather poorly sorted, although well-sorted grainstones also occur locally. Its colour, generally poorly sorted nature, coarser grain size, and content of irregularly-shaped peloids help to distinguish it from the underlying Cleeve Cloud Member, but in some cases it may resemble the younger Notgrove Member of the Aston Limestone Formation. Commonly , the top surface is a hardground. Although this has been noted at a few localities in the west of the area, where the member is overlain by the Aston Limestone Formation, the hardground seems to be particularly well-developed in the east, where the Aston Limestone is absent, and the Scottsquar Hill Member is overlain directly by the Clypeus Grit (Salperton Formation). In this situation, the hardground surface is generally heavily encrusted with oysters, and shows abundant, long, vertical annelid borings, much like those extending from the presumably contemporaneous hardground at the top of the Notgrove Member (see below).

At several localities [around 143 156; 147 177;140 175; 110 170] pure white carbonate mudstones (micrites) and marls occur within the Scottsquar Hill Member. This is the facies of the Oolite Marl; it commonly occurs at the base of the member, but in some cases occurs higher in the succession, often interbedded with 'Upper Freestone facies' as described above. It typically contains common fossils, dominated by brachiopods, notably the characteristic *Plectothyris fimbria* (J. Sowerby).

South of Sweetslade Farm, the 'Oolite Marl' appears to form a local, mound-like reef at the base of the member [1393 1746]. It contains common corals such as *Donacosmilia wrighti* (Edwards & Haime), serpulids (*Sarcinella*) and bryozoa. The upper part is bored, pervasively limonitised, and also contains solution voids, suggestive of subaerial weathering. It seems likely that this local ?palaeokarst surface is contemporaneous with that locally affecting the top of the Cleeve Cloud Member [e.g. 1490 1666; 1470 1789] (see above). It is also possible that the bored top surface of the reef may also be contemporaneous with the hardground commonly developed on the top of the Cleeve Cloud Member; at this locality [1393 1746], it is uncertain whether or not a hardground is presen beneath the reef. A well-developed palaeokarst, affecting the top of a similar coralline reef developed on top of the Yellow Guiting Stone at Oathill Quarry [101 289], Temple Guiting (Moreton-in-Marsh district) was exposed during 1993-4. Assuming that the correlation of the Cleeve Cloud Member and Yellow Guiting Stone is correct (see above), it may well represent the same emersion event as that just described, which may therefore prove to be a useful marker for correlation.

The Scottsquar Hill Member is (or was) exposed at localities C, D, O, Q, S, V, X and Y. Of these, 'Oolite Marl' facies was recorded at localities V, X and Y. Richardson (1933) and Baker (1981) also recorded it at LocalityD (Turkdean Quarry [1084 1711]), although the current section there shows only 'Upper Freestone' facies.

3.4 BIRDLIP LIMESTONE FORMATION: HARFORD MEMBER

At Locality C (Newtown Quarry, Turkdean [1116 1670]), Richardson (1925a, 1933) recorded 0.46m of white, grey and black clay above limestones of the Scottsquar Hill Member; these he ascribed to the Snowshill Clay. The latter is now considered part of the Harford Member, the uppermost unit of the Birdlip Limestone Formation. The quarry is now obscured, but the clay is not evident at outcrop nearby, and has not been noted elsewhere in the Farmington area. Clays at this horizon are developed locally in the area to the west, however [e.g. 097 177; 092 183] (Barron, 1995).

3.5 ASTON LIMESTONE FORMATION

The Aston Limestone Formation is exactly equivalent to the Middle Inferior Oolite of previous accounts. It is present only in the western part of the area, due to eastward overstep by the Salperton Limestone Formation. Where fully developed within this area, the formation has a probable maximum thickness of about 5m, and is divisible into three members, the Lower Trigonia Grit, Gryphite Grit and Notgrove members, in ascending order. More typically, the thickness is only 2 to 3m, and towards its limits, the succession is commonly incomplete. The individual members of the formation are not separated on the map.

The absence of the Aston Limestone in the east is confirmed by exposures at localities Q, S, V, W, X, Y and (probably) O. However, the precise limits of the formation beneath the Salperton Limestone within the area are somewhat uncertain in detail. This results both from the general difficulty in tracing the outcrop (largely due to obscuring debris, chiefly of Clypeus Grit, from upslope) and from the similarity of the Notgrove Member to the Scottsquar Hill Member (Birdlip Limestone Formation) where the latter is overlain directly by the Salperton Limestone. Nevertheless, it appears that the overstep of the Aston Limestone is more complex than indicated by Buckman (1897, pl. 46; 1901, pl. 6; see also Arkell, 1933, fig.36, p. 199). The main outcrop of the formation extends along the main valley of the Sherborne Brook, approximately as far east as Smith's Barn [124 178]. Elsewhere in the region, the formation is generally absent, though small isolated areas are present to the north-west of Smith's Barn [119 184] and in the neighbourhood of Dryground Barn [133 182].

The Lower Trigonia Grit Member forms the basal unit of the Aston Limestone Formation. It comprises grey to brown finely sandy, ooidal limestone often fairly shelly, particularly with large bivalves (notably myids and trigoniids). It commonly contains brown ferruginous ooids and 'ropes' of serpulid worm tubes (*Sarcinella*). It also contains occasional corals such as *Thecosmilia*. The Lower Trigonia Grit grades upwards into the Gryphite Grit Member (including the Buckmani Grit of some accounts), which is a grey to brown sandy, generally rather rubbly limestone with variable amounts of ooids and shell debris. It commonly contains thick-shelled oysters (*Gryphaea bilobata* J de C Sowerby) and belemnites (*Pachyteuthis*). A late form of the ammonite *Graphoceras* (MGS 2363) found near Dryground Barn [1348 1840] probably came from the Gryphite Grit; it suggests the Lower Bajocian Discites Zone. The Notgrove Member (formerly Notgrove Freestone) is a grey, well-sorted, medium-grained ooid grainstone. The upper surface, beneath the Salperton Formaton, is commonly encrusted by oysters, and intensely bored by annelid worms, with straight, vertical borings, generally 1 to 2mm in diameter, extending down many centimetres into the rock. The Notgrove Member appears to be absent in the more easterly parts of the outcrop of the Aston Formation, for example near Dryground Barn.

The lower part of the Aston Limestone Formation is poorly exposed in Turkdean Quarry (Locality D), and it must formerly have been exposed at Newtown Quarry (Locality C) to the south. At the latter locality, Richardson (1925a; 1933) inferred the presence of Lower Trigonia Grit only, but brash in the fields nearby indicates that all three members of the formation are present hereabouts.

3.6 SALPERTON LIMESTONE FORMATION: UPPER TRIGONIA GRIT MEMBER

The Upper Trigonia Grit Member forms the basal unit of the Salperton Limestone Formation (Upper Inferior Oolite) over much of the Cotswolds region. Typically, it is a hard, grey to brown, very shelly, shell fragment and ooid grainstone to packstone, and is overlain non-sequentially by the younger Clypeus Grit Member (Richardson, 1929; 1933). Within the Farmington area, it appears to be generally absent, probably having been overstepped by the Clypeus Grit to the west. This is confirmed by sections at four localities (D, O, Q and S), where Clypeus Grit has been seen to rest directly on either the Aston Limestone Formation or the Birdlip Limestone Formation. It is, however, possible that Upper Trigonia Grit is present locally; Richardson (1904b; 1925a; 1933) noted it in quarries at Turkdean (Locality C [1116 1670]), Sweetslade Farm (Locality V [1423 1828]), Gilbert's Grave (Locality X [1430 1876]) and Foxhill Farm (Locality Y [1474 1856]). Only for Locality V are any details given; there it is described as a grey, slightly shelly, sandy rock, 1.17m thick, containing oysters, '*Terebratula globata*' (= *Sphaeroidothyris globata* J Sowerby and/or *Stiphrothyris tumida* Davidson) and a form of rhynchonellid. At Locality Y it was 0.36m thick. It remains possible that Richardson's supposed Upper Trigonia Grit is merely a particularly shell-rich, and well-cemented facies at the base of the Clypeus Grit, such as occurs south of Starvall Farm [143 158 area], and also immediately south of the area [1438 1499] (Sumbler, 1994b), .

3.7 SALPERTON LIMESTONE FORMATION: CLYPEUS GRIT MEMBER

The Clypeus Grit is the younger of the two units which comprise the Salperton Limestone Formation (Upper Inferior Oolite), and is generally its sole representative in the Farmington (see above). The Clypeus Grit crops out in the valleys of the southern half of the area, and more extensively in the northern part. The thickness is commonly difficult to estimate from outcrop due to the effects of cambering. Nevertheless, there appears to be little or no systematic variation across the area (in contrast to the older units of the Inferior Oolite), with about 12m being a probable average, within a likely range of about 10 to 15m.

The Clypeus Grit is typically a yellowish cream to white, very coarse-grained ooid and shell fragment packstone, containing occasional beds of coarse ooid grainstone. Large ovoid peloids, and 'pisoliths' (?intraclasts or grain aggregates) are also common; the latter seem to be characteristic of the formation. The beds are commonly fossiliferous, with common echinoids (*Clypeus ploti* Salter; especially near the top), brachiopods (notably

Stiphrothyris spp. and *Sphaeroidothyris*), and moulds of myid bivalves. Ammonites occur rarely; in the eastern part of the area a specimen (MGS 2216) of *Parkinsonia (Gonolkites) subgalatea* (S. S. Buckman) was found in field brash [1472 1781]. Given the location of the find it can only have come from the lower part of the formation, yet indicates the early Bathonian *Zigzagiceras zigzag* Zone. The specimen is very similar to part of the poorly preserved type specimen, and the form is similar to *P. (G.) convergens* and may indicate a *convergens* Subzone age. *Parkinsonia* sp. (MGS 2217) was also collected from the topmost part of the Clypeus Grit [1469 1904], and *Parkinsonia pachypleura* S. S. Buckman (MGS 2214) was also collected from just beyond the western boundary of the area [0970 1995]; again it indicates the *Zigzagiceras zigzag* Zone.

The Clypeus Grit was formerly exposed at several localities (Appendix 1) but generally few details of the strata have been recorded. Currently the best exposures are at Locality S [1452 1555] which displays the basal 1.5m of the formation, and Locality W at Gilbert's Grave [1430 1886], where about 4m near the base are very poorly exposed. In the road cutting immediately to the north-east, [1435 1891 to 1443 1901] the higher part of the formation was formerly exposed; there Marker (1973) recorded the upper c. 8.3m of the formation, so that the cutting and quarry together must formerly have provided a section through the whole formation. In the cutting and elsewhere in the north-east of the area [notably 137 182; 143 184; 148 189] , the top of the Clypeus Grit is a hardground, with a planed top surface (cutting across grains, fossils etc), showing annelid and bivalve borings, and commonly with encrusting oysters. Elsewhere, the topmost bed of the formation is strongly burrowed, but the junction with the overlying Chipping Norton Limestone may be gradational.

4 MIDDLE JURASSIC: GREAT OOLITE GROUP

4.1 CHIPPING NORTON LIMESTONE FORMATION

The Chipping Norton Limestone forms the basal unit of the Great Oolite Group. It is present principally in the north-eastern part of the Farmington area, where it forms broad dip-slopes and is probably from 1 to 2m in thickness. In the western and southern parts of the area it generally appears to be absent, although it is thinly represented south and west of Notgrove Manor [111 192; 100 200], and may conceivably be present elsewhere, the outcrop being obscured by downwashed material fron the overlying Fuller's Earth. To the east of the Farmington area, the formation thickens significantly; it is generally about 5m thick near Burford.

The Chipping Norton Limestone is characterised by grey to brown, fine-grained sandy and ooidal limestones, containing a variable proportion of shell debris. It generally produces a brash of thin, but uneven flags in the fields. The limestones often have a somewhat 'dirty' appearance, due to the inclusion of argillaceous material, and there are probably interbeds of clay within the formation, particularly at the base. Within the Farmington area, the rock is typically intensely burrowed, in some cases with brown clay infills to the burrows. It commonly contains mudflakes and small lignite fragments. Locally, shelly limestones with abundant oysters occur [e.g. 146 188], and also grey sandy limestone with *Praeexogyra acuminata* [e.g. 138 183]. A specimen (MGS 2215) of the ammonite *Parkinsonia* sp. was collected from brash near Sweetslade Farm [1452 1846]; the genus ranges from the *garantiana* to the *zigzag* zone (late Bajocian to early Bathonian).

4.2 FULLER'S EARTH FORMATION

The Fuller's Earth Formation is named from the Bath district, where the upper part of the formation (Upper Fuller's Earth) yields commercial fuller's earth (clays rich in the mineral smectite or calcium montmorillonite). The Fuller's Earth of the present region corresponds only with the Lower Fuller's Earth of the type area, and does not contain smectite in significant quantities. In the Farmington area, the Fuller's Earth Formation is estimated to range from about 12 to 15m in thickness. Borehole 3 [1180 1649] proved 12.8m, and Borehole 19 [1111 1522] proved 13.2m (not bottomed). The formation crops out principally on the valley slopes of the area; in this situation, it is generally very poorly exposed, as the outcrop is largely given over to pasture, and is also commonly affected by landslip. The formation also forms wider outcrops around Cold Aston, and capping the hilltops near Notgrove Manor in the north-western corner of the area, and at Farmington Grove in the south-east.

The Fuller's Earth is dominated by grey mudstones, which weather to produce a dark brown clay soil. Cores of boreholes 18 [1116 1522], 19 [1111 1522] and 20 [1212 1502] in the south of the area, recorded by B C Worssam, R A Ellison and R J Wyatt in 1980, are described mainly as dark to medium greenish or olive grey silty mudstones, commonly with scattered shell debris. The formation also contains sporadic thin beds and lenses of greyish brown, planar-laminated, calcareous sandstone or sandy limestone ('tilestone'), and hard, bluish-grey, cream to yellow-weathering micritic limestone with abundant small oysters, notably *Praeexogyra acuminata* (J. Sowerby) ('Acuminata Marble'). Grey, fine-grained argillaceous limestones also occur. The limestones occur particularly in the upper part of the formation. Boreholes 18, 19 and 20 proved up to 1.12m of fine-grained grey to yellowish brown laminated sandstone or siltstone immediately below the Taynton Limestone. In these boreholes, *P. acuminata* is common in the mudstones 2 to 3m below the top of the formation; this may correspond with the *acuminata* Bed (=Lower Fuller's Earth Unit 6) of Penn and Wyatt (1979), who regarded it as a widespread marker bed.

Limestones become particularly common in the northern part of the area. A unit of limestones with interbedded mudstones at the top of the formation has been mapped (and indexed 'ls') around Cold Aston, where it forms a broad capping to the hill spurs south of the village. The unit may reach up to 5m or so in thickness. An exposure at Locality J [1168 1975], west of Cold Aston, showed 1.31m of pale grey, platy and fissile, finely ooid grainstone with mudflakes, interbedded with grey, laminated fissile calcareous sandstone ('tilestone'), resting on clays with *P. acuminata.* The fine-grained ooid grainstones are particularly common hereabouts [120 198 area]; they resemble lithologies found within the overlying Taynton Limestone of this area, so that the mapped junction of the Fuller's Earth and Taynton Limestone is somewhat poorly defined locally.

The limestones of the Cold Aston area are similar and probably equivalent to those that underlie the Taynton Limestone in the area to the north (Moreton-in-Marsh district; Sheet

235), near Eyford (around Huntsman's Quarry [126 252]), Naunton [114 233] and Sevenhampton [033 217]. These strata have traditionally yielded tilestones known as Cotswold Slates, and the Cotswold slates may be regarded as a member of the Fuller's Earth Formation. They were assigned to the Stonesfield Slate Series by Richardson (1929) (the Stonesfield Slate Beds of Arkell, 1933), but this name is inappropriate, as the Stonesfield Slate of the type locality (Stonesfield in Oxfordshire) lies within the Taynton Limestone (Boneham and Wyatt, 1993). The strata (at Huntsman's Quarry) have more recently been named the Eyford Member (or Eyford Sandstone Member) of the Sharp's Hill Formation (Ager et al., 1973, p. 7) although the formational term Fuller's Earth is more appropriate as the type Sharp's Hill Formation is typified by a more marginal marine facies than is developed at Eyford (Arkell, 1933). Boneham and Wyatt (1993) assigned the Cotswold Slates to their newly defined Charlbury Formation (type locality Charlbury Quarry, near Stonesfield). However this name too is inappropriate; although the Cotswold Slates correspond in stratigraphical position and (probably) age to the Charlbury Formation of the type area, they are of significantly different facies and, due to their failure across the Vale of Moreton Axis, are not contiguous with it.

A considerable fauna including reptiles, fish and insects has been recorded from the Cotswold Slates (Strickland and Buckman, 1844; Brodie and Buckman, 1845). It is similar to, though less diverse than that from Stonesfield; for example, no mammals are known from the Cotswold Slates. The Cotswold Slates of Eyford have also yielded the ammonite *Procerites progracilis* (Cox and Arkell) and *P. mirabilis* Arkell, indicative of the Progracilis Zone (Middle Bathonian) (Savage, 1963; Torrens, 1969).

4.3 TAYNTON LIMESTONE FORMATION

The Taynton Limestone Formation forms extensive outcrops capping the interfluves in the southern part of the Farmington area, with more restricted outcrops in the north, between Turkdean and Cold Aston. It is estimated to range from about 7 to 11m in thickness. In its most typical development (as at Farmington Quarry, Locality M [130 169]; Appendix 1) the Taynton Limestone is a white, cream or pale brown, coarse-grained, generally well-sorted ooid and shell fragment grainstone that forms a flaggy brash in the fields. The ooids generally have a relatively large shell fragment nucleus, with a thin, white, soft 'chalky' coating of accreted carbonate; they often appear in marked colour contrast to the darker groundmass of the rock. The shell debris is typically concentrated in thin bands on cross-bedding foresets. Exposures show that the strata are almost invariably cross-bedded; the fine exposures at Farmington Quarry (Locality M) show large-scale cross-bedding with cosets more than 5m thick. Foreset azimuths here and at other localities (including the type locality of Taynton, near Burford) indicate that the predominant current directions were from the north and east.

Fossils (CW 543-9) collected (by B C Worssam) from the formation at Farmington Quarry include serpulids, *Entolium?, Placunopsis socialis* Morris & Lycett, *Plagiostoma cardiiformis* J. Sowerby, *Praeexogyra acuminata* (J. Sowerby), *Praeexogyra hebridica* (Forbes), *Spondylopecten?* and *Trigonia* sp. Richardson (1933) also noted rhynchonellids; these may be forms of *Kallirhynchia*, which is often quite common in the formation. During the recent survey, a specimen (MGS 2208) of the ammonite *Procerites* cf. *tmetolobus* S. S. Buckman was found in a loose block of massive white shell fragmental oolite on the floor of Quarry 3 [1300 1680]; it evidently came from a nearby outcrop, about 5m below the top of the section. The species is generally attributed an early Bathonian age.

In the western and northern parts of the area, the formation contains interbeds of pale brown fine to very fine-grained ooid grainstone and, more rarely, greyish brown, finely sandy 'tilestone' with ooid wisps. Another lithology occasionally found is coarsely shelly, commonly oyster-rich limestone. These lithologies are very similar to those that typify the Hampen Formation (see below). Within the Taynton Limestone, they become more dominant to the west and south-west of the Farmington area, and the formation eventually passes into an expanded Hampen Formation (known as the Througham Tilestones in the Gloucester district; 1:50 000 Sheet 234) by interdigitation. This relationship may have been recognised by Hull (1857, p.53), who equated the tilestone and associated beds of Througham and Sevenhampton Common (see below), with the freestones of Farmington and Taynton.

Borehole 20 [1212 1502] (drilled for the Northleach By-pass site investigation) proved 1.45m of buff, sandy, ooidal and shell-detrital marl, with ooid grainstone bands, in the middle part of the formation. Borehole 18 [1116 1522] also proved 0.50m of silty marl, 3.3m above the base of the formation. It rested upon 0.1m of calcareous sandstone with a bored top surface, which passed down into more normal ooid grainstone as described above. Richardson (1933, p. 42) describes a similar succession at Locality B [1146 1600] (Appendix 1), with an oyster-rich limestone and clay (containing *Praeexogyra acuminata* J Sowerby; beds 5 and 4 of Appendix 1) overlying a thin bored sandy limestone (Bed 3), with cross-bedded, ooidal limestone (Bed 1) below. Mapping shows quite unequivocally that all these strata lie within the Taynton Limestone. However, Richardson (1933) regarded them as part of the 'Stonesfield Slate Series' (see above), which underlies the Taynton Limestone, equating them with the Sevenhampton Marl and overlying 'Ostrea acuminata Limestone' of Sevenhampton Common and Hampen Railway cutting (Moreton-in-Marsh district; see Richardson, 1929). Similarly, at Farmington Quarry (Locality M [130 169]), the beds now assigned to the basal Hampen Formation were equated with the Sevenhampton Marl, Ostrea acuminata Limestone and Rhynchonellid Bed of the 'Stonesfield Slate Series' (Richardson, 1933, p. 42). The underlying limestones (i.e. the Taynton Limestone of this account) were therefore deduced to be a local development within the Stonesfield Slate Series (despite their obvious similarity to the Taynton Limestone of the type locality), and were named the 'Farmington Freestone'.

Richardson's classification may partly have stemmed from the belief that *Praeexogyra acuminata* is restricted to levels below the Taynton Limestone. Whilst it is true that *P. acuminata* characterises the lower part of the Great Oolite Group, and *P. hebridica* the upper, the stratigraphic value of these species should not be overestimated. In any case, recent collecting (by MGS) from Richardson's so-called Sevenhampton Marl at Farmington Quarry reveals the presence of both *P. acuminata* and *P. hebridica* (see below), in accord with its true horizon at the base of the Hampen Formation. Indeed, even at Sevenhampton and Hampen Cutting, the Sevenhampton Marl (beneath the Taynton Limestone; Appendix 1) contains both species. For this reason, Arkell (1933, p. 279) renamed Richardson's Ostrea acuminata Bed, the Acuminata-Sowerbyi Bed (*Ostrea sowerbyi* = *Praeexogyra hebridica* Forbes). In fact, there is no reason to suppose that the beds identified by Richardson as the Sevenhampton Marl, Ostrea acuminata Limestone and Rhynchonellid Bed at various localites necessarily represent the same horizons in each case; the beds so named show considerable lithological variation from place to place.

The invalid concept of a laterally persistent Sevenhampton Marl, and of a Farmington Freestone at a level beneath the Taynton Limestone, has confused subsequent attempts at correlation within the Great Oolite (e.g. Green and Melville's (1956) classification of the Stowell Park Borehole). Nevertheless, it seems possible that the lower part of the Taynton Limestone in the Farmington area corresponds in age with beds included (by Richardson, 1929) in the Stonesfield Slate Series at Sevenhampton and Hampen.

The Taynton Limestone was traditionally regarded as a premier building stone, and there were many quarries in the Farmington area, some of which are recorded in Appendix 1 (Localities B, G, L, M, P, Z). The stone is still worked as a freestone at Farmington Quarry (Locality M). Farmington is one of the more westerly workings; to the west and north of Farmington Quarry, the proportion of good freestone in the formation diminishes (see above); most of the quarries in the region were concentrated in the Windrush valley to the east, at Sherborne, Windrush, the Barringtons, Taynton and Burford (see Arkell, 1947).

4.4 HAMPEN FORMATION

The Hampen Formation forms extensive outliers overlying the Taynton Limestone in the western and central parts of the area. It is estimated to range from about 6 to 8m in thickness. The soil on the outcrop is dominantly a brown clay, but limestone brash is locally abundant. Information from boreholes and exposures (mostly in adjoining areas) show that the formation comprises rather calcareous mudstones interbedded with limestones in roughly equal proportions, with limestone locally dominating. The most common and characteristic limestone type is a grey to brown, extremely fine-grained ooid grainstone, generally containing a proportion of fine-grained quartz sand and, in some cases, wisps of relatively coarse-grained white ooids (like those of the Taynton Limestone). These rocks are typically ripple-laminated, fissile and form a flaggy brash, often showing burrows and trails on bedding surfaces. They commonly have a faint bituminous smell when freshly broken, and may contain mudstone clasts, which weather out to leave voids in the rock. Where particularly sandy, they grade into calcareous sandstone much like the 'tilestones' of the Fuller's Earth. Lenses of shell-fragment and ooid grainstone resembling the Taynton Limestone also occur in places, particularly near the base of the formation, as in the exposures at localities A and M (Appendix 1). Rubbly sandy limestones lacking bedding structure also occur, particularly at higher levels in the formation.

Micritic, bluish grey to cream or brown-coloured oyster-rich limestones occur sporadically; they resemble the 'Acuminata Marbles' of the Fuller's Earth, but generally contain larger oysters dominated by forms classified as *Praeexogyra hebridica* (Forbes). They are especially common near the base of the formation, where they are associated with oyster-rich clay. Marly clay of this type was exposed immediately above the Taynton Limestone at Farmington Quarry (Locality M, Quarry 1, bed 2; [1297 1676]; Appendix 1). Fossils from a washed sample (MGS 2213) include bryozoa, *Praeexogyra acuminata* (J.

Sowerby), *P. hebridica* (Forbes), *Radulopecten vagans* (J. de C. Sowerby) and echinoid spines. The mixture of the two forms of *Praeexogyra* may indicate a horizon roughly equivalent to that of the Fuller's Earth Rock. Richardson (1933. p. 42) regarded this bed as the equivalent of the Sevenhampton Marl of Sevenhampton Common (Moreton-in-Marsh district; see Richardson, 1929), which underlies the Taynton Limestone there (see discussion of the 'Farmington Freestone', above). This classification may partly have stemmed from the belief that *P. acuminata* is restricted to levels below the Taynton Limestone. Whilst it is true that *P. acuminata* characterises the lower part of the Great Oolite Group, and *P. hebridica* the upper, the stratigraphic value of these species should not be overestimated; there is no reason to suppose that this bed equates with the Sevenhampton Marl of Sevenhampton; it is almost certainly younger.

The basal part of the formation was exposed during construction of the shallow cuttings along the Northleach By-pass during the 1980s. A specimen of *Procerites* (belonging to Mrs E Jenkins of Hampnett) was collected at this time [probably from a point between 100 162 to 114 155]; the matrix confirms that it came from the Hampen Formation. According to Torrens (1969) the only other ammonite known from the formation is the holotype of *Procerites imitator* (S S Buckman) from Fritwell, in Oxfordshire.

4.5 WHITE LIMESTONE FORMATION

The White Limestone Formation is the youngest Jurassic formation to crop out in the Farmington area; only the basal part, perhaps 6m or so in thickness, is represented. These beds belong to the Shipton Member, the lowest of the three members which make up the complete White Limestone succession, which is about 20 to 25m in total thickness in adjoining areas. It crops out in the south-western corner of the area [101 151], and as faulted outliers in the north-west, between Turkdean and Notgrove.

The soil on the outcrop is typically a brown loamy clay containing a generally sparse brash of subangular limestone fragments. The strata are dominated by grey to white, coarse-grained peloidal wackestones and packstones, together with subordinate very fine grained ooid grainstones. Due to recrystallisation, the latter rocks commonly appear uniform, structureless micrites on superficial examination. Near Pountwell Farm, buff, well-sorted ooid grainstone and platy sandy limestones also occur. These lithologies were quarried, probably for walling stone, from a roadside pit [1033 1867]; there is now no exposure.

5 STRUCTURE

Over most of the area, the general dip of the strata is from about 0.7° to 1.5° towards the south-east. In the eastern part of the area, the dip swings round (through south) towards the west-south-west. There, the beds lie on the western limb of a gentle anticline, with a north to south trending axis which passes a short distance to the east of the margin of the Farmington area. This anticline is related to the buried Moreton Axis, the margin between the Worcester Basin of Mesozoic sedimentation to the west, and the Palaeozoic massif of the London Platform to the east.

Localised steeper dips are generally related to faulting or superficial structures. For example, a dip of 20° to the south-west, measured in the Hampen Formation at Kitehill Barn [1017 1980] is terminal bending against a fault which runs a few metres to the north. A northward dip of 15° in the Leckhampton Member at Locality H [1180 1706] is a result of valley bulging of the subjacent Upper Lias (see below).

The principal area of faulting lies in the north-west, where several intersecting fractures with a west - east or north-west - south-east trend have been mapped. The maximum throw, on the most northerly fault near Kitehill Barn, is of the order 30 to 35m, where White Limestone is juxtaposed against Clypeus Grit.

The effects of superficial (non-diastrophic) structures, i.e. those related essentially to the present topography, are widespread in the area. The processes involved are poorly understood, but are generally acknowledged to be related to phases of periglaciation during the Quaternary era. Cambering is probably present to some extent on virtually all the steeper slopes of the area; its effect is to increase the lateral and vertical extent of the outcrop of the cambered beds, commonly giving a misleading impression of thickness. The Taynton Limestone is most strongly affected, because of its situation above the relatively incompetent Fuller's Earth. Deformation and outward movement of the Fuller's Earth clay has allowed the overlying Taynton Limestone to collapse, and extend downslope as a 'camber' made up of blocks separated by superficial faults with small displacements ('dip-and-fault'). Cambering of the Taynton Limestone is particularly pronounced in the steep valleys in the south of the area, and most especially on south-facing slopes, probably because the predominantly southward tectonic dip of the strata facilitates the downward movement of the limestone blocks. In many cases, cambering is closely associated with lanslipping of the Fuller's Earth (see below), and cambered blocks of Taynton Limestone may be involvved in the slips.

Valley bulging is most pronounced along the valley of the Sherborne Brook, where Upper Lias and the overlying Leckhampton Member commonly occur at elevations up to 15m higher than might be expected from the succession seen on the adjoining slopes. The principal cause is the upward 'squeezing' of the incompetent Upper Lias in the valley floor, presumably due to the lesser overburden pressure along the line of the valley. The upward movement of the clay may deform the overlying beds, which commonly dip relatively steeply away from the axis of the valley (e.g. at Locality H). In many cases, the bulging is asymmetric with respect to the valley; this is particularly noticeable in sinuous sections, where much greater uplift occurs on spurs on the inside of a bend [e.g. 115 170; 132 175; 148 169; 148 166], than on the opposite steep bluff on the outside of the bend.

6 QUATERNARY

6.1 ALLUVIUM

Alluvium has been mapped along the narrow floodplain of the River Leach in the south-west of the area, and downstream from the perennial source of the Sherborne Brook in the south-east. The source is in Bittam Copse [147 152], where water rises from springs at the base of the Inferior Oolite (see also Richardson, 1925b). At the surface, the alluvium is composed of brown, somewhat peaty loam, commonly containing small granules of tufa (precipitated calcium carbonate). Dredgings show that the loam is generally underlain by a gravel composed of small rounded pebbles of locally-derived limestone. The deposit is generally likely to be less than 2m in thickness.

6.2 RIVER TERRACE DEPOSITS

A small area of river gravel occurs on the south bank of the Sherborne Brook in the south-east of the area [149 152]. The deposits are composed of subrounded limestone gravel, and form a gently sloping terrace, approximately 1.5m above the floodplain. They are contiguous with, and may extend beneath the alluvium, and on this basis are assigned to the First (youngest) Terrace, probably being broadly contemporaneous with the First Terrace of the River Windrush (Sumbler, 1994a; in prep.). They probably do not exceed 2m or so in thickness.

6.3 HEAD

Head deposits are extensive in the area, with minor accumulations of solifluxion debris and hillwash (colluvium) occurring on slopes and in valleys. Only the thicker, laterally more extensive deposits are indicated on the map; these occur principally along the valley of the Sherborne Brook and its 'tributary' valleys. The deposits generally comprise brown loamy clay overlying limestone gravel, and may locally be up to 3m thick. They are generally much like the alluvium mapped lower down the valley, and likewise have a flat, floodplain-like top surface, although this is often buried beneath younger solifluctate and colluvium at the margins. The deposits are undoubtedly largely water-lain, and may be regarded as ancient alluvium, formed when the perennial water table stood higher than at present, and permanent streams flowed in the valleys.

6.4 LANDSLIP

Extensive landslips affect the Fuller's Earth Formation, particularly in the valleys in the south of the area. Generally, the landslipped ground can be recognised by its characteristic topography: typically, the upper part of the slopes appear to be affected by multiple, small-scale rotational slips, and the lower parts by mass flows, which may obscure parts of the outcrop of the Clypeus Grit. Rarely, fresh scars and open fissures suggest that slips are still sporadically active in places.

7 ECONOMIC GEOLOGY

Most of the limestone formations of the area have been quarried in the past. The Cleeve Cloud Member was extensively quarried in the valley immediately south of Turkdean, providing stone for the local buildings. It is still exposed at Locality D. Other quarries exploiting the Member include those at localities X and V, where it was quarried in conjunction with the overlying Scottsquar Hill Member and Clypeus Grit. The latter was principally used for roadstone, and was dug for this purpose at several other sites in the area, including locality K. According to Hull (1857, p. 55) the Fuller's Eath around Aston Blank (i.e. Cold Aston) yielded 'good slates and flagstones'. The main quarries were to the north of Cold Aston [118 208], and there are no obvious signs of working within the confines of Sheet SP 11 SW. The principal source of premium building stone in the area was the Taynton Limestone, which was exploited at a number of sites, and is still worked at Farmington Quarry (Locality M [130 169]) under the name of Farmington Stone. The quarry employs about 30 personnel, and sawn freestone blocks, fireplaces, lintels etc., are produced on site.

Locally abstracted groundwater was formerly the only source of potable water in the area; some details are given by Richardson (1930). Some dwellings and isolated farm buildings are still supplied by springs or wells. Most of the springs occur at the base of the Taynton Limestone, which rests on impermeable Fuller's Earth clays [e.g. 107 152; 130 153; 128 162; 131 161; 138 162; 141 161; 112 187; 107 188; 111 196]. Springs and seepage lines are particularly common on east or south-facing slopes, because of the predominant south to south-eastward dip of the beds which influences the flow of the water. Powerful springs also occur at the base of the Inferior Oolite Group, which rests on impermeable Upper Lias, in the valley of the Sherborne Brook in the south-eastern corner of the area (see above. At the time of survey (1993-4) the Sherborne Brook was intermittent, passing beneath the surface near Holy Hill Coppice [114 170] and reappearing near Picket Down Plantation [144 155], close to the permanent springs in Bittam Copse [147 152] (see above). A tributary stream also rises from semi-permanent springs in Fish Pond Coppice [111 196] near Notgrove Manor. The other valleys are generally dry, but surface streams flow during wet seasons.

With regard to proposed building construction in the area, it should be recognised that natural and artificial cut slopes in the Fuller's Earth are likely to be potentially unstable, whether or not currently affected by landslips. The Fuller's Earth, and other clay-rich beds notably in the Upper Lias and Hampen Formations, are also likely to be subject to shrinkage or swelling depending on moisture content, which may present foundation stability problems. Construction on limestone formations is generally likely to present fewer problems. However, the possible presence of old infilled quarry workings, or of subsurface voids resulting from cambering should be considered.

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APPENDIX 1. SECTIONS

Thicknesses are given in metres. Some of the sections below are paraphrased from other publications (notably Richardson, 1933), but stratigraphic classification of all sections is by MGS. In many cases, sections have been renumbered from the base. Nomenclature used for fossils has not generally been revised.

A [1018 1573] Manor Farm, Hampnett; section behind barns (MGS, 1994).

Hampen Formation (lower part)	
3. Limestone, cream-brown, coarse-grained shell fragment and ooid grainstone.	0.70
2. Marl, buff, with shelly patches; parts indurated into a rubbly limestone.	1.2
1. Limestone, brown, hard, massive, very fine-grained, somewhat sandy ooid grainstone.	0.4

B [1146 1600] Quarry near the Isolation Hospital, Northleach (Richardson, 1933, p. 42). The site is now marked by a depression in the field; there is no exposure.

Taynton Limestone Formation	
5. Limestone packed with *Ostrea* [=*Praeexogyra*] *acuminata.*	0.10
4. Clay, yellowish-brown, marly, also packed with *O.* [*P.*] *acuminata.*	0.20
3. Limestone, dense, fine-grained, sandy, riddled with borings - some crypts of *Lithophaga.*	0.10
2. Marl, pale yellow, and stone.	0.20
1. Limestone, white, ooidal, with much shell debris, locally false-bedded; occasional large crushed rhynchonellids.	2.44

Richardson classified bed 1 as the 'Ragstone', bed 2 and 3 as 'Sevenhampton Marl' and bed 5 as 'Ostrea Acuminata Limestone', implying regional correlations (Richardson, 1929, p. 106) which do not seem to be justified (see main text of this report). His correlation with Farmington Quarry (Location M) is also incorrect; there, the named beds in question are higher in the succession.

C [1116 1670] Newtown Quarry, Turkdean. The following section is based on Richardson (1925a, p. 83; 1933, p. 29). Beds 4 to 6 (for which no thicknesses are given) were evidently not well exposed. Mapping indicates that the Aston Limestone is fairly well developed hereabouts, and both the Gryphite Grit and Notgrove members are represented in brash only 250m to the east [1141 1674], and are are probably present at this site. The quarry is now (1994) almost totally obscured, except for c. 0.4m of hard, poorly sorted ooid grainstone of Bed 1.

Salperton Limestone Formation: Clypeus Grit Member	
6. A little rubble, pisolitic; *Terebratula globata.*	?
Salperton Limestone Formation: Upper Trigonia Grit Member	
5. Rubble, non-pisolitic; usual fossils.	?
Aston Limestone Formation : Lower Trigonia Grit Member	

4. A piece of marly limestone containing a specimen of *Tubithyris degenerata* (Upton).	?
?Birdlip Limestone Formation: Harford Member (Snowshill Clay)	
3. Clay, white and grey.	0.30
2. Clay, black.	0.16
Birdlip Limestone Formation: Scottsquar Hill Member	
1. Limestone, ooidal, regularly bedded, but 'open-jointed' and shattered.	3.05

D [1084 1711] Turkdean Quarry (MGS, 19/04/94). Old quarry by roadside; face almost vertical, with strong vertical jointing, and in a very dangerous condition, thus only examined superficially. Mapping nearby shows that both the Aston Limestone and Scottsquar Hill Member are generally thicker than in this exposure, and it is possible that the uppermost beds (4 to 6) are affected by cambering; in particular, the Clypeus Grit may not be in situ.

Salperton Limestone Formation: Clypeus Grit Member	
6. Reddish brown clayey loam with small limestone pieces.	1.0
Aston Limestone Formation	
5. Cryoturbated blocks of mainly rubbly, very poorly bedded limestone, intermixed with buff marl.	2.0
Birdlip Limestone Formation: Scottsquar Hill Member	
4. Limestone, massive, fawn-grey, poorly sorted oolite with some micrite pisoliths. In sections a few metres to the north, the lower part is developed as fawn to cream, rubbly peloidal packstone to wackestone. Sharp base.	1.1
Birdlip Limestone Formation: Cleeve Cloud Member	
3. Limestone, massive, buff, moderately to very well-sorted, medium to fine-grained oolite, with sharp, planed top.	0.37
2. Limestone, as above, passing down into coarser oolite with shells and shell debris. Sharp undulating base.	0.52
1. Limestone, fairly massive, but with signs of low-angle cross-bedding; white to yellowish fine to medium-grained oolite with some coarser shell fragmental layers; becoming better sorted downwards; an even-grained oolite grainstone.	c.4.5

Baker (1981, fig. 2) also recorded this quarry, indicating 1.4m of Scottsquar Hill Member mainly of Oolite Marl facies, the lower part dominated by 'oomicrite', and the upper part by 'marl'. He incorrectly indicates Clypeus Grit resting directly on the Upper Freestone. This or a nearby quarry was recorded by Richardson (1933, p. 29):

Birdlip Limestone Formation: Scottsquar Hill Member	
4. Marl, white and yellow.	0.71
3. Limestone hard, white marly; *Plectothyris fimbria* (J. Sowerby).	0.61
2. Marl, white, and rubbly limestone; *Natica leckhamptonensis* Morris and Lycett, *Lobothyris whitakeri* (Walker).	0.51

Birdlip Limestone Formation: Cleeve Cloud Member

1. Freestone, regularly bedded but open jointed.	9.1

Hull (1857, p.40) recorded the Cleeve Cloud Member as 14.0m thick (see main text), resting on 4.26m of 'Yellow Sandstone' (Leckhampton Member).

E [1013 1761] Small exposure in old quarry by track, 650m west-north-west of Turkdean Church (MGS, 1993).

Birdlip Limestone Formation: Scottsquar Hill Member

1. Limestone, buff, very coarse to medium grained, poorly sorted, poorly bedded oolite.	1.0

The total thickness of the Scottsquar Hill Member is estimated to be about 5m hereabouts.

F [1062 1763] Section in north side of trackway, 250m north-north-west of Turkdean Church. (MGS 1994)

Taynton Limestone Formation	
3. Limestone, pale buff, coarse ooid grainstone with interbeds of brown, fine-grained oolite.	0.7
Fuller's Earth Formation	
2. Clay, brown, with abundant small oysters.	0.3
1. Limestone, very sandy, grey, massive.	0.2

G [1208 1668] Old quarry 550m east-north-east of Leygore Manor (MGS, 1994).

Taynton Limestone Formation

1. Limestone, buff to white, coarse to medium-grained, ooid and shell fragment grainstone; Massive, becoming thinly bedded near ground surface.	1.4

H [1180 1706] Section in valley side, 1130m east-south-east of Turkdean Church (MGS, 1994).

Leckhampton Member

1. Limestone, ferruginous, rust-brown, level-bedded, rubbly-weathering, very fine-grained sandy oolite.	0.4

The beds dip at c. 15° degrees to the north (into the hillside), probably as a result of valley bulging (see main text).

I [1018 1982] Small exposure adjacent to Kitehill Barn (MGS, 1993).

Hampen Formation

1. Sandstone, calcareous, grey, fissile 'tilestone', with layers of pale grey, coarse shell fragment and ooid grainstone.	0.7

The beds dip at c. 20° to the south-west, in contrast to the generally sub-horizontal disposition of the strata hereabouts; this is due to terminal bending against a fault that passes immediately north of the site.

J [1168 1975] Temporary exposure 770m north-west of Bangup Barn (MGS, 1994).

Fuller's Earth Formation	
2. Limestone, pale grey, finely ooidal, platy and fissile, with mudflakes; some interbeds of grey, laminated fissile calcareous sandstone ('tilestone').	1.3
1. Clay, fawn, calcareous, with *Praeexogyra acuminata.*	0.4

K [1344 1602] Old quarry 500m south-south-east of Hill Barn, Farmington. The quarry, about 4m deep is heavily overgrown, but a small section remains exposed (MGS, 1993).

Salperton Limestone Formation: Clypeus Grit Member	
1. Limestone, yellowish brown to cream, coarse-grained peloid and ooid packstone to grainstone; common *Clypeus.*	1.1

This quarry is probably that 'about half way between Farmington and Hill Barn' mentioned (without details) by Richardson (1933, p.31). He gave its position as 'half a mile west of Farmington Church' ; this should read half a mile *north*-west of the church.

L [1333 1648] Old quarry 70m east of Hill Barn, Farmington (MGS, 1993).

Taynton Limestone Formation	
1. Limestone, yellowish buff, medium to coarse-grained shell fragment and ooid grainstone; cross-bedded, flaggy.	2.5

M [130 169] Farmington Quarry. Operated by Farmington Stone Ltd, Northleach, Cheltenham, Glos GL54 3UZ; Tel 0451 860280. Owner/Manager J Barrow (MGS 11/05/93)

Quarry 1 [1298 1696]; the oldest workings now exposed, showing partly back-filled galleries and walled-up cuttings.

Ancient quarry waste.	1.4
Original soil, brown with limestone pieces.	0.3
?Hampen Formation	
3.Limestone, fairly flaggy, disturbed in upper layers; brown to buff, poorly sorted medium to coarse-grained ooid and shell fragment grainstone with sporadic small oysters.	0.9
2. Marl, fawn to buff, with common layers and nodules of soft cream tufa; abundant tiny oysters.	0.3
Taynton Limestone Formation	
1.Limestone, pale buff, coarse to medium-grained ooid and shell fragment grainstone; cross-bedded.	c.3

The marl band Bed 2 (Richardson's 'Sevenhampton Marl'; see below) is prominent for c. 50m or more across the face. In Quarry 3 it apparently lies in the subsoil. The following section, after Richardson (1933, p. 42), is almost certainly of Quarry 1:

5. Limestone, flaggy, ooidal.	0.61
4. Marl, yellow, with layers of clay of variable thickness.	0.36
3. Limestone, packed with small specimens of *Ostrea* [= *Praeexogyra*] *acuminata*; *Placunopsis socialis* (Morris and Lycett); in two beds separated by a clay parting.	0.20
2. Marl, yellow, locally clayey and stony, with traces of a bored bed; typical *O.* [= *P.*] *acuminata* plentiful.	0.38
1. Freestone, mostly massive-bedded, ooidal, shelly - the ooids and shell debris occurring in wisps. The top stratum is hard and full of oysters and also contains a rhynchonellid, *Lima cardiiformis* s.l., *Plicatula* sp.	5.18

Richardson (1933) classified bed 5 only as Taynton Limestone, regarding the underlying strata as part of the 'Stonesfield Slate Series' (which are now classified with the Fuller's Earth Formation), with beds 2, 3 and 4 equating respectively corresponding with the Sevenhampton Marl, Ostrea Acuminata Limestones and Rhynchonella Bed of the Moreton-in-Marsh district). The underlying freestone (Bed 1) was regarded as a 'new' unit, the 'Farmington Freestone' (see main text).

Quarry 2 [1297 1687] exposes c 7m of Taynton Limestone with large-scale cross-bedding, azimuths 040 to 030° (i.e. currents from north-east). Old workings filled with spoil can be seen in section, together with a gull infilled with brown sticky clay soil and corroded limestone blocks.

Quarry 3 [1299 1679], in the southern part of the site, is being actively worked (1993-4). The section, up to 5m high, shows pale buff to yellowish, medium to very coarse-grained oolite and shell-fragment oolite grainstone, in courses 0.2 to 0.5 thick. Within courses, bedding is picked out by layers of shell debris, typically a few centimetres thick. Large-scale cross-bedding affects the entire face (i.e. cosets 5m + high); dip up to 25 degrees, currents from 330 to 020° (i.e. roughly north). In the floor of the quarry, rare scours with ripple-marks also indicate north-south currents. At the top of the face, some debris of brownish oolite with *P. hebridica* indicates remnants of the Hampen Formation.

N [1316 1749 to 1324 1748] Old quarries 900m east-south-east of Smith's Barn, Turkdean (MGS, 1994).

Birdlip Limestone Formation: Cleeve Cloud Member	
2. Limestone, yellow to brown, fine-grained ooid grainstone with abundant *Propeamussium.*	1.5
Gap.	?
Birdlip Limestone Formation: Leckhampton Member	
1. Limestone, very sandy, brown and orange mottled, grey cores where fresh, rubbly, with moulds of bivalves.	2

O [1236 1841] Old quarry, 550m north of Smith's Barn. Exposure very poor (MGS, 1993).

Salperton Limestone Formation: Clypeus Grit Member	
3. Limestone rubble, brown; coarse-grained peloid packstone.	0.3
Birdlip Limestone Formation: Scottsquar Hill Member	
2. Limestone, fawn, poorly sorted ooid packstone to grainstone; brown and ferruginous in upper part, with planed top.	0.3
Gap	c. 2
Birdlip Limestone Formation: Cleeve Cloud Member	
1. Limestone, buff to yellow, fine-grained, well-sorted ooid grainstone; seen as debris.	?

P [1270 1990] Cold Aston Quarry Old quarry, 100m west of church, now used as allotment gardens. Small exposure remains in north face. (MGS, 1994)

Taynton Limestone Formation	
1. Limestone, grey to cream, coarse-grained, shell fragment and ooid grainstone; flaggy, cross-bedded (currents from east).	2.5

Q [1437 1503] Old quarry, now totally obcured. The following section ('Quarry ½ mile E.S.E. of Farmington') is based on Richardson (1933, p. 32)

Salperton Limestone Formation: Clypeus Grit Member	
7. 'Typical'; *Clypeus ploti*, *Terebratula globata* etc. Seen in an opening above the quarry.	?
?Gap	?
Birdlip Limestone Formation: Scottsquar Hill Member	
6. Oolite, flaggy.	0.15
5. Marl.	0.10
4. Limestone.	0.20
3. Marl, yellowish.	0.15
Birdlip Limestone Formation: Cleeve Cloud Member	
2. Limestone, ooidal, irregularly bedded, bored; top surface waterworn and covered with oysters.	1.22
1. Limestone, brown, whitish locally.	3.66

Richardson originally classified beds 2 to 6 as Lower Freestone, and bed 1 as 'Yellow Stone', the supposed equivalent of the Pea Grit Series. The present classification is somewhat tentative; the nearby Duckleston Quarry [1525 1492] (Richardson, 1933, p.32) also showed a bored, oyster-encrusted limestone surface, there interpreted by Sumbler (1994a) as the top of the Upper Freestone, i.e. Scottsquar Hill Member. However, mapping shows that there are similar bored, oyster encrusted hardgrounds at the top of both the Scottsquar Hill and Cleeve Cloud members hereabouts, and in favour of the preferred classification is the presence of a yellowish marl (bed 3) at the base of the Scottsquar Hill Member in both sections.

R [1491 1527] Small scrape in river bluff, 1.25km east of Farmington Church (MGS, 1993).

Birdlip Limestone Formation: Cleeve Cloud Member
1. Limestone, white, fine-grained well-sorted ooid grainstone; broken up and disturbed by ?cryoturbation or superficial movements. 0.6

S [1452 1555] Old quarry 900m east-north-east of Farmington Church; exposure poor (MGS, 1993).

Salperton Limestone Formation: Clypeus Grit Member
2. Limestone, grey, packstone with coarse-grained, yellow micritised pellets; rubbly, common terebratulid brachiopods; rarer rhynchonellids and myid bivalves. 1.5
Birdlip Limestone Formation: Scottsquar Hill Member
1. Limestone, pale grey, hard, well-sorted medium-grained ooid grainstone, passing down into pure white, soft, poorly cemented, moderately well sorted to poorly sorted ooid packstone. Some pieces of hardened, brown to grey bored and oyster-encrusted hardground amongst fallen debris, presumably from top. 2

T [1408 1816] Section behind barn at Sweetslade Farm (MGS, 1993).

Birdlip Limestone Formation: Scottsquar Hill Member
3. Limestone, pale grey, poorly sorted peloid and ooid wackestone to grainstone. 0.4
Birdlip Limestone Formation: Cleeve Cloud Member
2. Limestone, pale greyish to yellowish brown, fine-grained ooid grainstone, platy. 1.5

U [1353 1848] Old quarry 330m north-east of Dryground Barn; heavily overgrown (MGS, 1993).

Birdlip Limestone Formation: Scottsquar Hill Member
1. Limestone, pinkish-buff, poorly-sorted ooid packstone to grainstone. 0.3

V [1423 1828] Sweetslade Farm Quarry. There is now (1994) no exposure at this site, which is partially infilled and heavily overgrown. The following section (renumbered from the bottom upwards) is based on that given by Richardson (1904b, p. 403):

Salperton Limestone Formation: Clypeus Grit Member
7. Rubbly rock with typical lithic structure- pisolite-spherules; *Terebratula globata, Pecten cf. demissus, Myacites, Homomya gibbosa.* 0.41
Salperton Limestone Formation: Upper Trigonia Grit Member
6. Grey, slightly shelly rock, sandy: *Ostrea, T. globata*; the latter

is most abundant in the upper portion in association with a *Rhynchonella*; lower portion not very fossiliferous.	1.17
Birdlip Limestone Formation: Scottsquar Hill Member	
5. Brownish clay, oolite granules.	0.13
4. Limestone, ooidal.	0.28
3. Brownish clay, with a bed of oolite in places.	0.20
2. Whitish oolite, becoming rubbly at the base, and passing down into white and yellow marl with *Terebratula* [= *Plectothyris*] *fimbria* and *Rhynchonella subobseleta.*	0.86
1. Whitish oolite, rubbly at the top; *T.* [= *P.*] *fimbria*, *Lucina wrighti*, *Natica cincta*, *Pholadomya.* Some of the oolite-granules are brownish, rock more compact below.	1.02

Richardson (1933, p. 30, footnote) suggested that this was the quarry referred to by Hull (1857, p. 38; 'Section of the Inferior Oolite near Turkdean'), which showed 1.37m of 'ragstone' (= Salperton Formation), overlying 1.22m of 'Oolite Marl' (Scottsquar Hill Member), described as 'white argillaceous oolite and marlstone, interstratified with cream-coloured marls and shales'.

W [1430 1886] Gilbert's Grave Quarry No. 1 Currently (October, 1993), about 4m of Clypeus Grit are poorly exposed, and a piece of bored hardground (the top of the underlying Scottsquar Hill Member) was found loose. Higher beds of the Clypeus Grit are poorly exposed in the road cutting to the north-east. The following section is from Richardson (1925a, p. 83; 1933, p. 29)

Salperton Limestone Formation: Clypeus Grit Member	
5. Rubble.	0.30
4. Marl and rubble packed with *Terebratula globata*, *Clypeus ploti*, *Pholadomya sp.*	0.38
3. Limestone, comparatively few fossils.	1.68
2. Marl, yellow; *T. globata*, *C. ploti* and *Pleuromya sp.* common.	0.15
1. Limestone, massive bedded.	3.05

X [1430 1876] Gilbert's Grave Quarry No. 2. The following section is from Richardson, (1925a, p. 84; 1933, p. 30). The quarry is now heavily overgrown with no exposure, but the characteristics of the Cleeve Cloud and Scottsquar Hill members, each with a hardground at its top, can be seen in the surface of the track immediately to the south [1428 1870].

Salperton Limestone Formation: Clypeus Grit Member	
8. Rubble, some pieces with large ooids.	?
Salperton Limestone Formation: Upper Trigonia Grit Member	
7. Ragstone; *Acanthothyris spinosa* (Schloth.).	?
Birdlip Limestone Formation: Scottsquar Hill Member	
6. Limestone, hard, grey, obscurely ooidal; top surface level, bored and covered with oysters; indeterminable shell-fragments.	0.76
5. Marl, ooidal, buff, brown and yellowish with thin lenticles of	

grey clay, stony in places with a band of stone near the top; *Plectothyris fimbria* (J. Sowerby) (rare), isocrinoid ossicles.	0.53
4. Limestone, ooidal, pinkish.	0.38
3. Limestone, marly, ooidal, pinkish, with a layer of brown marly clay in the upper part. In the lower part pebbles of oolite occur and *P. fimbria* is common; *Epithyris submaxillata* (Morris).	0.61
2. Oolite, creamy yellow with a rubbly fracture; *P. fimbria.*	0.81
Birdlip Limestone Formation: Cleeve Cloud Member	
1. Limestone, sparsely ooidal, hard, regularly bedded.	1.06

Y [1474 1856] Foxhill Farm Quarry This old quarry is partly infilled and totally overgrown. The following section is based on Richardson (1933, p. 30).

Salperton Limestone Formation: Clypeus Grit Member	
6. Typical.	2.43
Salperton Limestone Formation: Upper Trigonia Grit Member	
5. Ragstone; usual fossils.	0.36
Birdlip Limestone Formation: Scottsquar Hill Member	
4. Limestone, ooidal, cream-coloured, rubbly in the lower portion. Top portion slightly bored; *Plectothyris fimbria* (J. Sowerby).	0.46
3. Marl and rubbly limestone; *Globirhynchia subobsoleta* (Davidson) (common), *P. fimbria*, *Epithyris submaxillata* (Morris), *Trigonia* sp.	0.53
2. Limestone, yellowish, with yellow ooids; *P. fimbria* in the upper part.	0.61
Birdlip Limestone Formation: Cleeve Cloud Member	
1. Limestone, very ooidal, obliquely bedded.	1.22

Z [?1223 1642]. Hull (1857, p. 56) gave a section of a quarry 'east of Leygore Farm, on the east side of the Roman foss-way'. There is no sign of a quarry at the point indicated by the grid reference, although the ground appears to be disturbed (?fill); an alternative site a little further north [1229 1648] is marked by a depression in the field, although the beds here may be higher in the succession. The section is renumbered from the bottom upwards.

Taynton Limestone Formation	
6. Coarse shelly oolite, obliquely laminated.	0.66
5. White, calcareous, ooidal marl.	0.10
4. White, argillaceous oolite.	0.15
?Fuller's Earth Formation	
3. Grey, calcareous slaty sandstone.	0.30
2. Brown and white sandy marl.	0.13
1. Grey sandy limestone.	0.61