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Geology of the Temple Guiting area

1:10 000 sheet **SP 02 NE**
Part of 1:50 000 sheet 217 (Moreton-in-Marsh)

A J M BARRON

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CONTENTS

1 INTRODUCTION

1.1 Introduction

This report describes the geology of the 1:10 000-scale sheet SP 02 NE (the Temple Guiting area) and should be read in conjunction with that map. This 25-km² area lies entirely within the 1:50 000-scale geological sheet 217 (Moreton-in-Marsh). The area was first geologically surveyed by Edward Hull at the 1:63 360-scale between 1852 and 1854 as part of the Old Series 1-inch sheet 44, published between 1856 and 1879 and described by Hull (1857). New Series Sheet 217, based on this map with minor amendments (addition of drift and the Chipping Norton Limestone by H G Dines), was published at the 1:63 360-scale in 1929, as was a descriptive memoir (Richardson, 1929). It was later republished at the 1:50 000-scale in 1975, with further minor changes in 1981.

The Temple Guiting area was surveyed by A J M Barron in 1996-97 as part of a resurvey of Sheet 217, a new edition of which is published (British Geological Survey, 2000). An account of the geology of Sheet 217 is also in preparation. In addition to geological data acquired through fieldwork, use was made of earlier geological maps, records of quarries, localities, boreholes and wells, and interpretation of commercially available aerial photography. The resulting map includes some important revisions to the earlier maps, mainly in the pattern of faulting and the additional detail in the stratal sequence. This report is based mainly on this latest work, but also incorporates data from other sources where appropriate, as indicated herein (see References and Information Sources). Measured sections from the lettered localities indicated on the map and referred to in the text are given in Appendix 1. Fossils collected during this and previous surveys were examined by Dr B M Cox (Cox, 1998).

The area of sheet SP 02 NE forms a part of the rolling limestone upland of the Cotswold Hills, which is dissected by the valleys of the Windrush and its tributaries, which run south into the Thames. The tributary of the Windrush running south-east from Lynes Barn to Guiting Power is called here the Castlett Stream for convenience. Part of the west-facing Cotswold escarpment, including a deep embayment above Hailes Abbey, lies in the west of the area; thus, it includes part of the Thames-Severn watershed. The picturesque villages of Temple Guiting, Ford and Kineton border the Windrush in the east of the area, which is predominantly arable farmland with some pasture. The large commercially-managed Guiting Wood is in the south. There is a working limestone quarry in the north near Ford.

Notes:
Both this report and the corresponding map (Geological Sheet SP 02 NE) give an interpretation of the data available at the date of compilation. They should be regarded as interim documents pending compilation of the account of the geology of Sheet 217; in particular, certain geological concepts and lithostratigraphical names may be subject to future revision.

This map depicts the disposition of the surface outcrops of the various bedrock and superficial deposits that are for the most part concealed beneath soil and vegetation. The geological boundary lines between these outcrops are mostly inferred from indirect evidence such as landforms and the characteristics of rock fragments (brash) and other material ploughed up in the soil, and from exposures of strata in quarries, 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 formations and faults which can be located (in the opinion of the surveyor) within approximately 20 metres on the ground ("observed" lines) are depicted with unbroken lines on the map, all others are shown broken.

Copies of the 1:10 000-scale map can be purchased from BGS, Keyworth, where records of boreholes and other data may also be consulted by prior arrangement. Copyright restrictions apply to the use of both the map and this report, and to the copying of the material thereof. The map and report are internal publications of the BGS and any information extracted from them should be acknowledged by the appropriate bibliographical reference.

Equivalent technical reports covering sheets to the north, west, east and south are available or in preparation:

SP 03 SE (Stanway)
SP 02 NW (Winchcombe)
SP 12 NW (Chalk Hill) WA/99/41
SP 02 SE (Hawling) WA/98/26

National Grid References are given in square brackets throughout. All lie within 100-km square SP (or 42) unless otherwise stated.

1.2 General account of geology

The oldest geological formation at outcrop in the Temple Guiting area is the Lower Jurassic Charmouth Mudstone Formation in the north-west around Hayles Fruit Farm. Overlying it are the silty mudstone beds of the Dyrham Formation, the thin limestone of the Marlstone Rock Formation and the Whitby Mudstone Formation, whose outcrops here are all almost entirely concealed by landslip. The Whitby Mudstone is also present in some of the valley bottoms, and is overlain by the predominantly limestone beds of the Middle Jurassic Inferior Oolite Group, subdivided into three formations (the Birdlip Limestone, Aston Limestone and Salperton Limestone), themselves divided into members (Table 1).

The Inferior Oolite Group strata are overlain by those of the Great Oolite Group, also of Middle Jurassic age and fully subdivided into formations. The oldest is the Chipping Norton Limestone, succeeded by the predominantly mudstone strata of the Fuller's Earth and the limestone strata of the Taynton Limestone - the last being the youngest solid formation in the area.

The solid strata at outcrop are generally flat-lying or gently dipping and are cut by a number of faults with throws of up to about 20 m. Superficial structures affect many of the Inferior Oolite and Great Oolite groups' outcrops.

The area is largely free of drift, although minor accumulations of head and alluvium occur mainly in valley bottoms. Landslipped material covers much of the slopes below the escarpment in the north-west.

The limestone formations have been widely exploited for stone in the past, and there is currently one significant active quarry. The Inferior Oolite Group is an important aquifer.

QUATERNARY:	
LANDSLIP	
HEAD	up to c. 3
ALLUVIUM	up to c. 3
MIDDLE JURASSIC:	
GREAT OOLITE GROUP:	
Taynton Limestone Formation	up to 2
Fuller's Earth Formation	
Eyford Member	c. 4
undifferentiated	c. 14
Chipping Norton Limestone Formation	3 to 5
INFERIOR OOLITE GROUP:	
Salperton Limestone Formation	13 to 15
Clypeus Grit Member	12 to 13
Upper Trigonia Grit Member	1 to 3
Aston Limestone Formation	11 to 20
Notgrove Member	7 to 13
Gryphite Grit Member	4 to 7
Lower Trigonia Grit Member	1
Birdlip Limestone Formation	35 to 57
Harford Member	0 to 7
Scottsquar Member	5 to 9
Cleeve Cloud Member	23 to 37
Leckhampton Member	3 to 6
LOWER JURASSIC	
LIAS GROUP:	
Bridport Sand Formation	0 to 4
Whitby Mudstone Formation	c. 95
Marlstone Rock Formation	1 to 2
Dyrham Formation	40 to 55
Charmouth Mudstone Formation	c. 20 seen

Table 1. Geological sequence proved within sheet SP 02 NE (Temple Guiting)
(approximate thicknesses in metres)

2 LIAS GROUP

2.1 Charmouth Mudstone Formation (c. 20 m seen)

The oldest strata at the surface in the Temple Guiting area are the grey mudstones of the Charmouth Mudstone Formation (the upper part of the 'Lower Lias'; Cox, Sumbler and Ivimey-Cook, 1999), which crop out in the extreme north-west around Hayles Fruit Farm, where they are almost entirely covered by landslip. Only the uppermost 20 m or so are at outcrop, but the full thickness of the unit was proved in the Guiting Power No.1 Borehole [SP 0855 2450] in the neighbouring area (Barron, 1998, appendix 2; SP 02 SE/1) in which it is about 268 m thick. The strata weather to grey-brown silty clay soils and grey to grey-brown smooth or silty clay, resulting from weathering of mudstone, was seen dug in a number of places on the outcrops.

2.2 Dyrham Formation (40 to 55 m)

The Dyrham Formation comprises a succession of sandy siltstone and silty mudstone beds, with thin beds of fine-grained sandstone. Its outcrop on the slopes above Hayles Fruit Farm in the north-west, is almost entirely concealed by landslip and thus its thickness is estimated by comparison with data from adjoining areas, including the Guiting Power No.1 Borehole [SP 0855 2450] to the south (Barron, 1998, appendix 2; SP 02 SE/1), in which it is about 60 m thick.

The formation weathers to a light, sandy and silty soil. An exposure of 0.35 m of calcareous sandstone (Appendix 1; Locality O) within the landslip on the outcrop may represent one of the sandstone beds. It contains bivalve fragments, including *Protocardia* and *Unicardium*? which are wide-ranging and not specific to the formation.

2.3 Marlstone Rock Formation

The Marlstone Rock Formation comprises 1 to 2 m of grey and orange-brown, ferruginous, silty, shelly limestone. Its crops out only in the north-west of the area, where it is entirely concealed by landslip. Thus, its location is largely inferred from the topography – spurs and convex breaks in slope – and information from adjoining areas.

2.4 Whitby Mudstone Formation

The Whitby Mudstone Formation comprises grey, silty, micaceous mudstone with thin nodular limestone beds in parts. Its estimated thickness is derived from the Guiting Power No.1 Borehole [SP 0855 2450] to the south (Barron, 1998, appendix 2; SP 02 SE/1), in which it is about 95 m thick. Cambering of the overlying Inferior Oolite Group strata in the north-west of the Temple Guiting area precludes a meaningful estimate from the formation's outcrop there.

Elsewhere, the formation crops out along the floors of the valleys of the Windrush through Temple Guiting and Ford, and its tributaries extending up to Lynes Barn [062 276] and Slade Barn Farm [077 287]. Its presence there has given rise to many springs (see **7.3**).

Grey mudstone is exposed in the bed of the stream [0797 2650] in Castlett Wood. The formation is exposed nowhere else, but gives rise to a heavy, grey-brown clay soil.

All of the outcrops of the Whitby Mudstone Formation along the valley floors are likely to be affected by superficial structures such as valley bulging (see **5.2**).

2.5 Bridport Sand Formation

A sequence of fine-grained calcareous sands, clayey towards the base, and widely developed in the Cotswolds above the mudstones of the Upper Lias, and beneath the limestones of the

Inferior Oolite, has been variously termed by authors the 'Upper Lias Sands' (Wright, 1856), 'Ammonite Sands' (Hull, 1857), Cotteswold Sands (Lycett, 1857) or Cotswold Sands (Arkell, 1933). In the Moreton-in-Marsh district between 1852 and 1854, Edward Hull mapped out extensive outcrops of sandy beds, and equated them with these strata. These included substantial outcrops in the Temple Guiting area, where the beds were estimated to be up to 9 m thick (Hull, 1857, p. 30). The current survey of the Moreton-in-Marsh district shows that most of these outcrops actually belong within the lower, sandy part of the Inferior Oolite (see Birdlip Limestone Formation). However, in the Gloucester and Malmesbury districts (Sheets 234 and 251) to the south-west, a thick sequence of Cotteswold Sands (now known as the Bridport Sand Formation of the Lias Group; Cox et al., 1999), comprising lenticular fine-grained sandstone beds interbedded with and passing into mudstone, is well developed at this level.

Notwithstanding the above, in the Temple Guiting area, the Bridport Sand may be fairly extensively developed, but it has been detected in only a few places, and is probably generally less than 4 m thick. Yellow-brown fine- to medium-grained sand was seen dug along the banks of the streams south-east of Kineton [0999 2619] and south of Castlett Stud [0893 2548]. The 4 m of brown sand and grey sandstone proved at the bottom of the Cotswold Hill Quarry borehole (Appendix 2; SP 02 NE/1) is also inferred to belong to the Bridport Sand, and the formation may be more extensive in these areas. Richardson (1930, p. 134) claimed that a 9 m-deep well at Lynes Barn [possibly at 0615 2791] was in the formation. Landslip below the escarpment in the west probably conceals further outcrops.

3 INFERIOR OOLITE GROUP

The Inferior Oolite of southern England is customarily divided into three units, the Lower, Middle and Upper Inferior Oolite. In the Cotswolds, these chronostratigraphical units correspond with the lithostratigraphically defined Birdlip Limestone, Aston Limestone and Salperton Limestone formations respectively, which are separated by unconformities (Barron, Sumbler and Morigi, 1997). The Inferior Oolite Group increases from about 60 to over 90 m thick from east to west across the Temple Guiting area.

Many of the outcrops of the group in the Temple Guiting area are profoundly affected by gulls (symbolised -G-) related to cambering (see **5.2**). Some gulls are interpreted to be grabens, but these structures are at too small a scale to represent on the 1:10 000 map with faults and downthrown blocks of strata. These are treated as simple topographic hollows, thus resulting in the unusual pattern of outliers and inliers in the area south of Pinnock Wood Farm [07 28 area].

3.1 Birdlip Limestone Formation

The Birdlip Limestone Formation is the thickest of the three formations comprising the Inferior Oolite Group in this area. It consists predominantly of ooidal limestones and reduces in thickness eastward from about 57 to 35 m. This thinning is a result of original thickness variations within the individual members (see below). In the Temple Guiting area, the strata are well exposed in Cotswold Hills Quarry (Appendix 1; Locality U), and elsewhere in the north Cotswolds (mainly on the escarpment at Crickley Hill, Cleeve Cloud and Leckhampton Hill).

In the past, the formation (as the Lower Inferior Oolite) has been subdivided into at least seven units (see Woodward, 1894; Richardson, 1929 and 1933; Arkell, 1933; Mudge, 1978). These have recently been adapted, redefined and renamed (Barron et al., 1997) as follows, in ascending order: Leckhampton Member (formerly Scissum Beds), Crickley Member (approximately Lower Limestone and Pea Grit), Cleeve Cloud Member (approximately

Lower Freestone including Yellow (Guiting) Stone, White Guiting Stone), Scottsquar Member (Upper Freestone/Oolite Marl) and Harford Member (Harford Sands/Snowshill Clay/Tilestone). In the Temple Guiting area, the characteristic lithologies of the Crickley Member seen further north and west (see Barron et al., 1997; Barron, 1999a) were only observed very locally, and thus it is not distinguished on the map.

In much of the Temple Guiting area it has not been possible to subdivide the Birdlip Formation on the map, due to lack of exposure, cambering, hillwash and vegetation cover, and it is shown undifferentiated. However, elsewhere, the four members are distinguished.

3.1.1 Leckhampton Member

The Leckhampton Member is thought to be present throughout the area and crops out above the Whitby Mudstone along the valleys of the Windrush and its tributaries and along the escarpment in the west. It consists of between 3 and 6 m of grey, rubbly, highly bioturbated finely sandy limestones, peloidal, shelly, shell-detrital and ooidal in part. The strata are ferruginous (sideritic?), weather to orange-brown and decalcify to sand, and give rise to very sandy, commonly stoneless soils.

The Leckhampton Member is well exposed in the Temple Guiting area. About 5 m of strata are exposed north of North Farmcote (Appendix 1, Locality P) and in the track near Castlett Farm (Locality S). About 2.6 m of thinly bedded strata were seen at Pinnock Farm (Locality Q) and lesser amounts 400 m to the north [0760 2847] and near Lynes Barn (Locality J). One metre of Leckhampton Member strata underlying the Cleeve Cloud Member is exposed near Temple Guiting (Locality V). Elsewhere, orange-brown sand and ferruginous, sandy, shelly limestone debris was seen dug and in the soil in a number of places on the outcrop.

The 8.7 m of strata between the Bridport Sand Formation and the Cleeve Cloud Member in the Cotswold Hill Quarry borehole (Appendix 2; SP 02 NE/1) may belong entirely to the Leckhampton Member, which would be the greatest thickness known in the area. However, it may also include Crickley Member strata (see 3.1.2).

The fauna of the Leckhampton Member includes bivalves, brachiopods and rare ammonites. The base of the member supports a spring line and outflows were observed at this level in several places (see **7.3**).

3.1.2 Crickley Member

The Crickley Member is not shown on the map in the Temple Guiting area and is thought to either have passed into the lower part of the Cleeve Cloud Member or have been overstepped by it (Sumbler, Barron and Morigi, in press). However, it is distinguished immediately to the north (SP 03 SE [066 300]) and its distinctive lithologies are seen locally in this area. In the extreme west, orange-brown or grey shell-detrital coarse-grained ooidal limestone is exposed in two places near Limehill Wood (0.3 m [0500 2585]; 1.0 m [0500 2540]) and blocks of a similar lithology were seen in field brash near Little Farmcote [0505 2848] and Pinnock Farm [0737 2823]. Shelly limestone between 14.80 and 17.80 depth in the Cotswold Hill Quarry borehole (Appendix 2; SP 02 NE/1) may represent the member.

3.1.3 Cleeve Cloud Member

The Cleeve Cloud Member of the Temple Guiting area comprises off-white, pale grey to pale yellow-brown fine- to coarse-grained ooid grainstones, well bedded and cross-bedded, bioturbated and shell-detrital in parts. Locally the lower part comprises darker orange- to yellow-brown bioturbated, shell-detrital, sandy, fine- to medium-grained ooidal grainstones and fine- to coarse-grained coated peloid limestones (the 'Yellow Guiting Stone', part of the 'Pea Grit Series' of Richardson, 1929, p.37), and passes up lithologically from the Leckhampton Member. The Cleeve Cloud Member is about 37 m thick in the north and west and thins south-eastwards to about 23 m. This is probably at least in part an original (sedimentological) variation. The thinning of the Cleeve Cloud Member is largely responsible for the reduction in thickness of the Birdlip Limestone Formation across the area.

The Cleeve Cloud Member is well exposed in the area; between 21 and 23 m of ooidal limestone is exposed below the Scottsquar Member in Cotswold Hill Quarry (Appendix 1, Locality U). A borehole in the floor of the quarry (Appendix 2; SP 02 NE/1) proved the lower beds, giving a total thickness here of 36.9 m, including at least 9.0 m of 'Yellow Guiting Stone'.

Beds of the 'Yellow Guiting Stone' are exposed near Castlett Wood (6 m; Locality R), south-east of Castlett Stud (1.0 m; [0935 2539]) and overlying the Leckhampton Member near Temple Guiting (1.5 m; Locality V). They were seen in temporary excavations at Guiting Power (Locality T) and Temple Guiting (Locality W). The upper, paler beds ('White Guiting Stone') are also well exposed in Crab Bottom Quarry (Locality H), where 9 m of beds were seen, and lesser amounts are exposed in disused quarries near Spoonley Farm (1.8 m; Locality A), Little Farmcote (2.6 m; Locality K) and Campden Lane (3.5 m; Locality L).

At many localities elsewhere in the north Cotswolds, a hardground marks the top of the Cleeve Cloud Member (e.g. Barron, 1999b, p. 9; Barron, 2000). However, no evidence of a hardground was seen in the Temple Guiting area where the top of the member is exposed (Localities L and U).

There are several other small degraded pits on the Cleeve Cloud Member outcrop. In arable fields, the angular or platy off-white to yellow-brown ooidal limestone debris may be abundant in the soil, as are individual ooids and fine sand.

3.1.4 Scottsquar Member

The Scottsquar Member is present throughout the Temple Guiting area, and is generally distinguished on the map. It forms broad outcrops on the upper slopes, notably west of Kineton [085 270 area], east of Temple Guiting [099 280 area] and around Pinnock Wood Farm [068 282 area]. It comprises 5 to 9 m of interbedded off-white to pale brown well-sorted medium- to coarse-grained peloid and ooid grainstone, pale shelly ooidal wackestone, carbonate mudstone or micrite and marl.

In the past, it has been observed (Buckman, 1887; Woodward, 1894; Richardson, 1929) that in the interval of strata now termed the Scottsquar Member, the marl and micrite beds tend to predominate at the base ('Oolite Marl' facies) and the peloidal and ooidal limestone above ('Upper Freestone' facies), although even then their variability and the difficulty of separating them (Buckman, 1895) was recognised. However, during the present survey of the Temple Guiting area and the wider north Cotswolds, this succession was not found consistently (see below).

In the Cotswold Hill Quarry (Appendix 1, Locality U, Beds 5 to 11), where the Scottsquar Member is 7.2 m thick, peloidal and ooidal limestones dominate the sequence, and subordinate clay and marl beds lie in the middle part. A stained and hardened surface on top of Bed 6 may indicate local hardground formation during the member's deposition, possibly relating to shoaling.

About 0.5 m of grainstone beds are visible north of Farmcote Wood Farm [0588 2724] and 0.5 m of marl or marly limestone are exposed at the base of the member in a quarry off Campden Lane (Locality L).

At Pinnock Farm Quarry (Locality N), Buckman (1901, p. 133) reported 1.2 m of limestone on 1.8m of "[lime]stone with layers of white calcareous sand". About 1.7 m of thin-bedded ooid grainstone is currently exposed. Richardson (1929, p. 56) recorded 1.0 m of limestone and marl with brachiopods and bivalves at the nearby Pinnock Quarry (Locality M), which is now filled in, and traces of marl and limestone with brachiopods in a disused quarry at Sheephill [0780 2535]. During the present survey, pale marl, micrite and wackestone debris with brachiopods was seen in spoil from a temporary excavation [0965 2983] reported by the owner to be up to 2.5 m deep "in sand".

On the outcrop, most of the above lithologies (grainstones, packstones, wackestones, pale micrites and marl) were commonly seen as field brash and material dug from burrows, but no consistent pattern of distribution was discernible. Blocks of extremely hard, pale grey, semi-porcellanous limestone were observed locally in field brash between Pinnock Wood Farm and Pinnock Farm [0699 2821 and 0730 2779 (specimen AMB 696)]. This lithology (similar to one observed in the Cirencester district (Barron, 1995, p. 12) is thought to be a result of post-burial diagenetic recrystallisation, as there are no signs of hardground formation.

The Scottsquar Member is renowned for its abundant and well-preserved brachiopods, including the distinctive and characteristic terebratulid *Plectothyris fimbria*. In some of the sections in the Temple Guiting area, they were recorded in limestone and marl beds (Appendix 1, Localities L, M, N and U) and are locally abundant in the characteristic pale-coloured marly soil, notably west of Crab Bottom [055 275 to 0585 2725], south-west of Castlett Stud [0863 2518], near Pinnock Farm [0720 2841 and 0777 2774], east of Temple Guiting [0985 2770 area] and east of Ford [0978 2912 and 0964 2990]. A specimen (AMB675) determined as *Plectoidothyris* sp. was collected from the brash near Pinnock Farm [0730 2791].

3.1.5 Harford Member

The highest beds of the Birdlip Formation in the Temple Guiting area comprise between 0 and 7 m of grey to orange-brown fine- to medium-grained sand and sandstone, grey to brown mudstone and pale grey and brown sandy, shell-detrital, peloidal, and ooidal limestone. Formerly subdivided lithologically into Harford Sands, Naunton Clay, Snowshill Clay and Tilestone, these are now grouped as the Harford Member (Barron et al., 1997), whose type section (Harford Railway Cutting) lies in the area to the south-east (Barron, 1999b, appendix 1, section O).

The Harford Member is present across almost the entire Temple Guiting area, but is possibly overstepped in the extreme east [0999 2720] by the Aston Limestone Formation. It is thickest (up to 7 m) in the centre of the area between Pinnock Wood Farm [069 282] and Farmcote Wood Farm [058 269]. The member has not been distinguished everywhere on the map due to poor exposure, vegetation cover and hillwash. However, it forms extensive outcrops around Pinnock Wood Farm [070 280 area], north-west of Slade Barn Farm [07 29] and between Cotswold Hill Quarry [082 293] and Sheephouse Barn [085 270].

In the Temple Guiting area, unlike other parts of the Moreton-in-Marsh district (e.g. SP13SW, SP13NW) the Harford Member cannot generally be subdivided, although a lenticular upper limestone bed is locally distinguished on the map at Pinnock Wood Farm [0685 2817], The Larches [0677 2772] and Cotswold Hill Quarry [0825 2932].

The member is exposed at the top of Cotswold Hill Quarry (Appendix 1, Locality U, Beds 12 to 19), where it comprises 3.85 m of beds, probably the full thickness here. In the quarry, the lowest beds (Beds 12 to 14) comprise a passage up from ooidal marl through grey clay into mottled medium-grained sand, totalling 1.5 m. This is overlain by 0.55 m of grey and greenish grey slightly shell-detrital clay (weathered mudstone; Bed 15), a 0.1 m-bed of shell-detrital limestone (Bed 16), 0.35 m of mottled slightly sandy and lignitic clay (Bed 17), topped by 1.35 m of sandy, bioturbated, shell-detrital, peloidal and ooidal limestone. Although the sequence seen here, and in some other parts of the Moreton-in-Marsh district, approximately mirrors Richardson's (1929, pp. 36, 38-41) "Naunton Clay", "Harford Sands", "Snowshill Clay" and "Tilestone" these terms cannot be universally applied and they may be unhelpful in some instances.

The member is not currently exposed anywhere else in the area, but the lower beds were formerly visible at Pinnock Quarry (Locality M) and Pinnock Farm Quarry (Locality N).

The member is poorly fossiliferous apart from scattered bivalve shells in some of the mudstone and limestone beds.

Contrary to Cave and Penn's (1972) view, no evidence was seen in this area of a non-sequence beneath the Harford Member. Indeed Buckman's (1901, p. 133) record at Pinnock Farm Quarry (Locality N) indicates some degree of vertical passage from interbedded limestone and sand of the Scottsquar Member into the sand and marl beds of the Harford Member, as does the presence in the Harford Member of both sandy and ooidal limestone varieties (Locality U, Beds 18 and 19).

At outcrop, the sand and clay beds of the Harford Member weather to a loamy, largely stoneless soil, and the limestone beds into sandy soils with platy limestone fragments. Large slabs of thinly bedded, grey sandy limestone or calcareous sandstone up to a metre across were seen on the edge of a field near Pinnock Warren [0656 2682]. These may have been collected from the outcrop. The sand beds may also be dug into by rabbits etc. The mudstone beds give rise to a few springs and seepages in the Temple Guiting area (see section **7.3**).

3.2 Aston Limestone Formation

The Aston Limestone Formation of the Temple Guiting area comprises between 11 and 20 m of grey and brown variously shelly, shell-detrital, bioturbated, sandy, iron-shot, peloidal and ooidal limestones and subordinate mudstones. The formation's type section, Harford Railway Cutting, and an important reference section (Barron, 1999b, appendix 1, sections O and P; Barron et al., 1997) lie to the south-east of the Temple Guiting area. The formation rests non-sequentially on the Birdlip Limestone Formation and is overlain non-sequentially by the Salperton Limestone Formation.

Utilising the nomenclature of Buckman (1895), the Aston Limestone Formation in the Temple Guiting area would previously have been divided into four 'members', in ascending order these were the Lower Trigonia Grit, Buckmani Grit, Gryphite Grit and Notgrove Freestone. The Buckmani and Gryphite grits have proved to be almost indistinguishable in many places, even where they are exposed elsewhere in the north Cotswolds. Thus the formation is divided into the Lower Trigonia Grit Member, the Gryphite Grit Member (Gryphite Grit plus Buckmani Grit) and the Notgrove Member (Barron et al., 1997). The brash of the first two can be difficult to tell apart where fossils are lacking. In addition, the Lower Trigonia Grit Member is very thin here and thus they are not separated on the map. However, the Notgrove Member is lithologically very distinctive, and it has been possible to separate it more generally on the map.

The variation in thickness of the Aston Limestone Formation results largely from erosion prior to the deposition of the Salperton Limestone Formation (the 'Bajocian Denudation' of Buckman, 1895). Overall, it displays a pattern of eastwards thinning in the Temple Guiting area. Some variation is due to local thickness variations of the individual members.

3.2.1 Lower Trigonia Grit Member

The Lower Trigonia Grit Member is probably present throughout the Temple Guiting area but it is unlikely to exceed 1 m in thickness. It is condensed relative to the areas further west, where it is up to 3 m thick (e.g. Barron, 1995; 1999a).

The member comprises grey, shell-detrital, sandy, bioturbated, fine- to coarse-grained ooidal/peloidal packstones and grainstones, highly fossiliferous in parts. Some of the coarser peloids are ferruginous (iron-shot), leading to the rock weathering to orange-brown colours. Richardson (1929, pp. 41, 60-61) and Parsons (1976, p. 59) report that the member in the north Cotswolds is marly and highly conglomeratic. However, this could not be confirmed in the Temple Guiting area, possibly due to a lack of sections where relatively unweathered strata could be examined. In addition, such limestone lithologies are likely to degrade rapidly where exposed, especially in intensively cultivated soils.

The member's fauna includes corals, bivalves, including trigoniids and *Gryphaea*, and tubes of the colonial serpulid worm *Sarcinella*.

In the Temple Guiting area, the member is no longer exposed, but was formerly visible in the 'Dirty Quarry' on Sudeley Hill (Appendix 1, Locality X). From Buckman's description (1901, p. 131), about 0.76 m of hard, sandy, shelly iron-shot limestone were exposed, but his estimate that a further 1.4 m were present above seems excessive (see 3.2.2). Richardson (1929, p. 60) tentatively reported about 0.3 m of rubbly, marly, iron-shot, highly conglomeratic limestone in a well north-east of Ford [0975 2987] which he attributed to the Lower Trigonia Grit Member.

The member's distinctive debris, locally highly fossiliferous, is commonly found in many places in the soil on the lower part of the Aston Limestone Formation outcrop. Orange-brown limestone rubble of the member was seen near Ford [0836 2926], east of Temple Guiting [0997 2808], near New Barn Farm [0857 2724], in Guiting Wood [0774 2685 and 0647 2639] and west of Castlett Stud [0828 2541. Similar debris containing *Sarcinella* was seen near The Gallery [0537 2505], on Longbarrow Bank [0528 2591 to 0519 2621], near Farmcote Wood Farm [0634 2656 and 0589 2720] and west of Lynes Barn [0510 2780]. A limestone fragment with an impression of the bivalve *Myophorella* (AMB 672) was collected near The Gallery [0520 2511] and limestone debris with corals was observed by Farmcote Wood [0649 2697] and near Pinnock Wood Farm [0688 2827]. A piece of sandy, bioturbated, iron-shot, ooidal limestone with a fragment of the ammonite *Sonninia* was collected (AMB 673) south of Farmcote Wood Farm [0611 2647]. Although this genus is more common in the Ovalis Zone of the Lower Bajocian Substage, it may also indicate the underlying Discites Zone (also Lower Bajocian) for the member, thus according with Parsons' (1980) conclusions.

3.2.2 Gryphite Grit Member

The Gryphite Grit Member comprises grey to brown, hard, shelly and shell-detrital, bioturbated, variably sandy, fine- to medium-grained peloidal limestone in rubbly medium beds. Sandy marl beds up to 0.05 m thick may separate these. The limestones of the lower part (formerly the Buckmani Grit) are commonly sandier and moderately iron-shot (i.e. similar to the Lower Trigonia Grit Member). The member is between 4 and 7 m thick in the Temple Guiting area, without any consistent pattern to this variation.

The fauna includes brachiopods, belemnites, worm tubes (*Sarcinella*) and bivalves including *Gryphaea*.

In the Temple Guiting area, the Gryphite Grit Member is no longer exposed, but was formerly visible in the 'Dirty Quarry' on Sudeley Hill (Appendix 1, Locality X). Here, Buckman (1901, p. 131) recorded about 3.5 m of shelly, sandy and rubbly limestone with bivalves, belemnites and brachiopods. It is thought that most or all of the 2 m of obscured strata below these beds also belong to the Gryphite Grit Member (contrary to Buckman's view), giving a possible maximum thickness here of about 5.5 m.

Richardson (1929, p. 60) reported about 2.0 m of pale yellow, sandy limestone with belemnites and bivalves in a well north-east of Ford [0975 2987] which he attributed to the Gryphite Grit Member.

The soil on the outcrop of the Gryphite Grit is commonly very stony. The brash is variably shelly, but typically grey-brown, rubbly, sandy, fine-grained peloidal limestone. This lithology with *Gryphaea* was collected from field brash near The Gallery [0560 2501 and 0536 2545], near Farmcote Wood Farm [0595 2645, 0528 2738 to 0510 2747], near Guiting Power [0853 2517] and near Ford [0824 2924 and 0835 2926]. A belemnite fragment was found on the outcrop near Pinnock Wood Farm [0695 2805].

3.2.3 Notgrove Member

The Notgrove Member comprises 7 to 13 m of hard, pale grey, fine- to coarse-grained ooidal and peloidal grainstone, sparsely shell-detrital in parts, with a sparse fauna of bivalves. The considerable thickness variation of the member in the Temple Guiting area is a result of erosion followed by non-sequential deposition of the Salperton Limestone Formation. The top of the Notgrove Member is a hardground (recrystallised, intensely bored and encrusted by oysters), indicating cementation prior to this erosion.

The Notgrove Member is thickest in the centre of the Temple Guiting area, near Farmcote Wood Farm [058 269 area]. In the large outlier west of Temple Guiting [08 28 area], the upper part is absent (due to post-uplift erosion), and the present thickness is difficult to estimate as the strata are affected by cambering (**5.2**), but is thought to exceed 12 m.

The member is currently exposed in several disused quarries in the Temple Guiting area. In Newtown Quarry (Appendix 1, Locality E), 1.9 m are exposed beneath the Salperton Formation. Richardson (1929, p. 55) reported that 4.0 m of the member was formerly exposed there. He described the top bed as bored, but this was not observed in the present survey, although signs of erosion (karstification?) were seen, indicating local temporary emergence.

The uppermost 0.8 m of the member are exposed in Straits ("Farmcott Wood") Quarry (Locality F) where the top is bored and extremely hard. Buckman (1901, p. 130) described 4.5 m of strata formerly exposed here, the lower beds being cross-bedded, and estimated a total thickness of 7.6 m. Cross-bedded strata in the Notgrove Member were observed 120 m to the north (Locality G) during the present survey, and its bored top was seen in a nearby small pit [0538 2696]. About 3 m of thin- to medium-bedded strata are exposed in a quarry at Roel Hill Farm (Locality B).

About 1.8 m of the Notgrove Member, overlain by the Upper Trigonia Grit Member were also formerly visible in Hawling Track Quarry (Locality C) 700 m south of Farmcote Wood Farm.

Richardson (1929, p. 60) reported about 1.7 m of 'typical' Notgrove Member in a well north-east of Ford [0975 2987]. This site is on the Gryphite Grit Member outcrop but is near a mapped gull, so the well may have penetrated locally down-faulted strata (see **5.2**).

The member's distinctive pale grey blocky brash, including bored and oyster-encrusted material from the hardground at the top, is common on the outcrop, particularly near The Gallery [057 251 area], around Farmcote Wood Farm [059 279 area], west of Guiting Power [0835 2510], near Newtown Quarry [0775 2565] and in the large outlier west of Temple Guiting [08 28 area]. A specimen (AMB 676) containing small bivalves (*Myoconcha*?) and a small indeterminate ammonite was collected from brash on Longbarrow Bank [0534 2588].

3.3 Salperton Limestone Formation

The Salperton Limestone Formation crops out only in the south-west part of the Temple Guiting area, and comprises between 13 and 15 m of shelly peloidal and ooidal limestones. The formation is equivalent to the Upper Inferior Oolite of Arkell (1933) and Parsons (1976). In this area, the Upper Inferior Oolite is divided into the Upper Trigonia Grit and Clypeus Grit, now formalised as members of the Salperton Limestone Formation (Barron et al., 1997).

The formation rests unconformably on the Aston Limestone Formation.

3.3.1 Upper Trigonia Grit Member

The Upper Trigonia Grit Member of the Temple Guiting area comprises 1 to 3 m of hard grey and brown shelly, medium- to very coarse-grained shell-detrital fine- to coarse-grained peloid and ooid grainstone and packstone. Some of the peloids may be ferruginous. It has an abundant macrofauna largely of brachiopods and bivalves, including trigoniids, and rare ammonites (Sumbler et al, in press). It is present at the base of the Salperton Formation throughout the Temple Guiting area. Where possible, the member has been differentiated on the map.

Almost the full thickness of the Upper Trigonia Grit Member is exposed in Straits Quarry (Appendix 1, Locality F), where 1.8 m of rubbly beds overlie the Notgrove Member. It is also partially exposed in Newtown Quarry (Appendix 1, Locality E), and was formerly seen in Hawling Track Quarry (Appendix 1, Locality C).

At the surface, the strata weather to orange-brown, and form rough slabs up to 1 m across with conspicuous large shell moulds, mostly of bivalves and brachiopods. A specimen (AMB 674) of the ammonite *Parkinsonia* was collected near Longbarrow Bank [0543 2598]. The member's brash is particularly abundant around Farmcote Wood Farm [058 269], east of Longbarrow Bank [057 261], near Newtown Quarry [0770 2565], near Castlett Wood [0775 2635] and west of Guiting Power [0830 2510].

3.3.2 Clypeus Grit Member

The Clypeus Grit Member forms the bulk of the Salperton Limestone Formation and crops out in the south-west part of the Temple Guiting area. It comprises 12 to 13 m of pale grey and brown moderately shell-detrital, fine- to coarse-grained ooidal and peloidal packstone and grainstone with abundant coarse- to very coarse-grained orange-brown-skinned subrounded aggregate grains (grapestones) and a common well-preserved macrofauna (see below). Generally, the Clypeus Grit Member's lower beds are more massive and thickly bedded and its upper beds are more rubbly and fossiliferous.

A hard, finely ooidal lithology with coarse-grained aggregate grains was observed close to the base of the outcrop south-west of Farmcote Wood Farm [055 266 area]. Near Castlett Wood, a rubbly shell-detrital limestone lithology with medium-grained ferruginous peloids was seen [0772 2633].

The member is not now exposed in the Temple Guiting area, but it was formerly exposed in a shallow quarry near Farmcote Wood Farm [about 0562 2670] (Richardson, 1929, p. 55).

The outcrops of the Clypeus Grit form several broad plateaus in the area, with a typically orangish stony soil with abundant loose grapestone grains. The fauna includes articulated bivalves and brachiopods, and whole echinoids, notably the characteristic *Clypeus ploti* Salter, and these weather out easily from the beds, and are often found loose. Fossils are particularly abundant in the soil near Hawling Grove [062 254 area] and Newtown Farm [073 254 and 076 258 area]. Ammonites are also relatively common, although none were seen during the present survey.

4 GREAT OOLITE GROUP

4.1 Chipping Norton Limestone Formation

The Salperton Limestone Formation is conformably overlain by the Chipping Norton Limestone Formation, which comprises 3 to 5 m of pale grey and brown well-sorted fine- to medium-grained ooidal grainstone with variable amounts of fine sand and medium- to coarse-grained shell debris and dark lignite. It typically contains common narrow burrows and whole oysters are fairly common. Locally a shelly or shell-detrital olive-grey to brown mudstone bed less than half a metre thick occurs at the base of the formation. The Chipping Norton Limestone Formation is not exposed in the Temple Guiting area.

Shelly clay was seen in the soil east and west of Newtown Farm [0697 2527 and 0721 2530] and clayey soil was observed in Guiting Wood [0610 2620 area]. These were derived from the basal mudstone bed.

The limestones of the Chipping Norton Limestone Formation weather to platy fragments in a brown finely sandy soil. The formation's outcrops are locally obscured by landslipped clay from the overlying Fuller's Earth Formation near Newtown Brake [068 254 area] (see **6.3**).

4.2 Fuller's Earth Formation

The Fuller's Earth Formation overlies the Chipping Norton Limestone Formation in the south of the Temple Guiting area. It comprises about 14 m of grey and olive grey silty mudstone with thin shelly, ooidal and sandy limestone and sandstone beds. These are best developed at the top of the formation where they are separated as the Eyford Member (see 4.2.1), which is distinguished on the map.

The Fuller's Earth Formation below the Eyford Member is not exposed in the Temple Guiting area. Spoil of grey silty mudstone was observed dug from a disused pit north-west of Newtown Farm (Appendix 1, Locality D). At outcrop, the mudstone beds weather to a very heavy grey-brown clay soil prone to waterlogging, with generally sparse limestone debris and are conspicuous in contrast to the limestone formation outcrops on air photographs. The mudstones are prone to landslipping (see **6.3** and **7.5**) which locally obscures the lower boundary. This, along with cambering of the overlying strata (see **5.2**), makes accurate estimation of the stratigraphical thickness of the formation somewhat problematic.

Springs and seepages arise at the top of the formation or within its outcrop (see **7.3**).

4.2.1 Eyford Member

The Eyford Member forms two small outcrops in the south of the Temple Guiting area. It comprises about 4 m of varied limestone lithologies including grey-brown, bituminous, thinly laminated and ripple-laminated, shell-detrital, finely very sandy limestone ('tilestone') and grey shelly finely ooidal grainstone. Fossils include the small oyster *Praeexogyra acuminata* (J Sowerby), plus other bivalves, gastropods and brachiopods.

The Eyford Member's type section lies just to the east (Huntsman's Quarry [SP 125 255]; Sumbler, 2000, appendix 1, localities E, F and G), but it is poorly exposed in the Temple Guiting area; 1.0 m of platy to medium-bedded finely ooidal and shell-detrital limestone is visible in a disused quarry north-west of Newtown Farm (Appendix 1, Locality D).

Brash of the various limestone lithologies is common in the clayey soil on the member's outcrops. The outcrops are affected by cambering (see **5.2**), making estimates of the stratigraphical thickness of the member somewhat unreliable.

4.3 Taynton Limestone Formation

The edge of an outcrop of the Taynton Limestone Formation lies in the extreme south of the Temple Guiting area [068 250]. It comprises up to 2 m of pale grey-brown shell-detrital medium- to coarse-grained ooid grainstone. The formation is not exposed. The soil on the outcrop is locally extremely stony, and large slabs of limestone may be ploughed up.

5 STRUCTURE

Regionally, the Jurassic strata in the mid-Cotswolds dip very gently (0.5 - 1.5°) to the south-east. Locally, dips steeper and in other directions than this may be deduced from outcrop patterns. Some of these relate to non-diastrophic, superficial structures (cambering, see **5.2**), but some dips in fault-bounded blocks may relate to fault movements, where dips of 3 to 7° are inferred, for instance south of Hawling Grove [060 251], between Campden Lane [056 257] and Newtown Farm [071 253], and east of Woodcott [080 250].

5.1 Faulting

The faulting observed in the area is generally of a fairly minor scale. The north-west-south-east fault near Newtown Farm [070 256] accords fairly closely with that recorded by Edward Hull in the original one inch to one mile survey of the district. A number of additional faults were identified in the present survey. Estimated displacements range from 2 to 15 m, but in places the throws deduced near to the surface may be modified by cambering (see below).

The dominant fault direction is west-north-west to east-south-east, which is also the predominant regional trend. No tectonic (diastrophic) faults are currently exposed, although they can be pinpointed in many places by sharp changes in the brash in fields, and are depicted in places by unbroken lines ("observed" lines) on the map.

The influence of faulting on topography is variable: two valleys roughly follow the line of faults (south of Newtown Farm [070 252] to Woodcott [077 250], from Woodcott [076 250] to the Manor House [082 258]), but elsewhere there is no apparent relation.

5.2 Superficial structures

The strata at outcrop in the Temple Guiting area are extensively affected by a variety of superficial structures, including valley bulging, cambering and gulls.

5.2.1 Processes

5.2.1.1 Valley bulging

According to Parks (1991), valley bulging takes place where the stress relief caused by erosion of a valley into a relatively flat-lying mudstone formation overlain by a more resistant 'cap-rock' (e.g. limestone or sandstone strata) produces a 'proto-bulge' in the floor of the valley, with joints in the cap-rock and probably a basal shear surface at some depth. Under permafrost (periglacial) conditions, frost-heave will enlarge the valley bulge and affect the valley sides and cap-rock (*5.2.1.2*). Further deepening of the valley by erosion of the ice-rich mudstone strata may accelerate lateral creep of the ice-rich slopes. Furthermore, the superincumbent load may aid creep and following thawing of ground ice, cause the soft material to undergo plastic flow, further enlarging the valley bulge.

The bulged mudstone material in the valley bottom is likely to be subject to further post-glacial erosion by running water, such that any topographic bulge form may be modified or removed. In addition, any lateral movement of the cap-rock towards the valley axis may result in bulged material being obscured.

5.2.1.2 Cambering associated with valley bulging

As a result of the creep and flow of the underlying valley-bulged mudstone beds, the cap-rock strata may be disrupted and laterally extended or lowered as a 'camber', comprising blocks separated by 'dip and fault structures' (series' of minor faults). These are generally parallel to the valley axis and penetrate to the base of the cap-rock sequence but not normally far beyond (Horswill and Horton, 1976, p. 434, fig. 6). However, the displacements on the faults is usually quite small (1 to 3 m) (Horswill and Horton, 1976, fig. 6), such that they may be undetectable solely from outcrop patterns (boundary offsets). Also, the faults may be closely spaced (up to 15 metres; i.e. too close to portray at 1:10 000-scale). This was recorded in a cap-rock sequence up to about 17 m thick by Horswill and Horton (1976, fig. 6). The average cambered cap-rock thickness quoted by Parks (1991) is 13 m.

5.2.1.3 Cambering on escarpments

In the Cotswolds (and elsewhere), creep and plastic flow also affect mudstone formations cropping out on escarpment edges and valley sides that have not undergone classic valley bulging. As a result, the vertical thickness of the mudstone beds reduces, and relatively thin cap-rock strata are affected by cambering as outlined above (*5.2.1.2*). However, outward (lateral) movement of thicker (20 to perhaps 90 m) blocks may cause vertical voids to open (gulls) parallel to the escarpment, which in parts of the Cotswolds may sustain cavities or even networks of caves (Self, 1995), or allow grabens to form containing disrupted or largely intact blocks of strata.

There is evidence in the Temple Guiting area (see 5.2.3) that similar structures may also occur away from the escarpment.

5.2.1.4 Gulls

Surface hollows (also known as gulls, and shown –G– on the map) may develop over voids formed as described above, by partial collapse, accelerated dissolution of more porous material or erosion. In softer or highly jointed strata these are likely to be partially filled with loose rock overlain by deep soil (see 5.2.3). They are relatively common in the north Cotswolds; described by Briggs and Courtney (1972) as 'ridge-and-trough' topography, and are particularly well developed in the Temple Guiting area.

5.2.2 Timing of cambering

As described above, cambering is largely a result of periglacial conditions, in force in this area during the Pleistocene. It is probably not a currently active process except along escarpments, where it may be ongoing and a precursor to landslip. Many of the effects of cambering must be considered potential engineering hazards (see **7.5**).

5.2.3 Cambering and valley bulging in the Temple Guiting area

The results of cambering and valley bulging are widespread in the Temple Guiting area, substantially affecting the strata in three general settings: along valley bottoms and sides, on plateaus and at escarpment edges. Notes on the map face highlight some of the locations of cambered strata, but the affected areas are likely to be more extensive than shown.

The outcrops of the Whitby Mudstone Formation along the River Windrush, Castlett Stream and their tributaries are inferred to be substantially valley bulged, and the adjoining slopes of Birdlip Limestone consequently are cambered. Although this has not resulted in the formation of surface gulls, the strata have been profoundly disrupted and steep dips into the hillside (around 50°) were measured in several places close to the valley bottoms [0896 2823, 0915 2748, 0983 2674]. Dips measured further away are generally less (e.g. 5 to 25°) and more variable in direction. In addition, where detectable from outcrop patterns, the Birdlip Limestone Formation strata show a general dip towards the valley, e.g. north of Ford [088

297], in Temple Guiting [095 281], south of Temple Guiting [097 274] and west of Castlett Stud [083 257].

A similar pattern of cambering is seen in the Birdlip Limestone Formation adjoining the escarpment edge in the north-west at Farmcote [062 290 area] and Little Farmcote [051 284 area]. However, there the adjacent Whitby Mudstone strata are thought to have undergone creep and plastic flow, leading to a reduction in vertical thickness, rather than classic valley bulging. Dips of 15 and 20° were measured in the Leckhampton Member strata at the scarp edge.

Further south, on the escarpment between Long Plantation [051 272] and Longbarrow Bank [054 260], a much greater thickness of Inferior Oolite Group strata is present. Here, intense gull formation has taken place with, in places, up to five linear surface hollows side-by-side, and parallel to the escarpment edge. These are up to 1.2 km long, 30 m across and 5 m deep. An open joint, about 0.1 m wide, of unknown depth and trending 170° (parallel to the escarpment and nearby gulls) was seen in Straits Quarry [0530 2703]. As the Whitby Mudstone Formation, which crops out below the escarpment to the west, is implicated in gull formation, this suggests that the subsurface structures must be of a similar order of depth as the cap-rock thickness (perhaps 70 to 80 m). This is considerably more than that recorded by Horswill and Horton (1976) and stated as an average by Parks (1991) (see *5.2.1.2*).

Examination of sections and geophysical surveys in the Naunton area (Barron, 1999b; Raines, Greenwood and Morgan, 1999) suggest that the structures underlying gulls in thick Inferior Oolite strata (such as those on the escarpment top here) may be grabens with steep and near parallel bounding faults extending down to the Whitby Mudstone, or shallower complex half-grabens. The infills include step-faulted or largely intact blocks of strata. In addition, further subparallel surface gulls occur on the slopes below Longbarrow Bank [050 260 area], overlying lesser thicknesses of Inferior Oolite strata. From this, it is inferred that the gulls related to the escarpment are the result of processes detailed above (*5.2.1.3*).

Away from the escarpment, sets of largely subparallel surface gulls occur in three areas on plateaus. Those at Pinnock Wood Farm [07 28 area] affect mainly the Scottsquar and Harford members and basal Aston Limestone Formation strata, although one extends down to the Leckhampton Member outcrop in the valley bottom [0713 2716] (and may be partly erosional in origin). Here, they are sinuous and branching, up to 800 m long, 70 m wide and 10 m deep. The gulls west of Temple Guiting [08 28 area] mainly affect the Notgrove Member outcrop, are fairly straight, up to 500 m long, 30 m wide and less than 3 m deep. Those east of Ford [098 294 area] affect mainly the Scottsquar and Harford members and basal Aston Limestone Formation strata. They are shorter, up to 50 m wide and less than 3 m deep. These sets are underlain by up to about 40, 60 and 50 m of Inferior Oolite strata respectively.

The mode of formation of the plateau-top gulls is uncertain. All are approximately parallel to the nearest stretches of the River Windrush and Castlett Stream. Although they are generally some distance away, if the gulls are inferred to overlie structures similar to those close to the escarpment, their genesis may be related to the valley bulging and adjacent cambering, possibly by a degree of lateral extension of the cap-rock strata. Alternatively, they may have formed by collapse into (possibly shallower) voids developed by dissolution along a regional joint set also exploited by the drainage. This would produce the parallelism seen, but implies no direct genetic relationship. It is also possible that the gulls result from some combination of the above processes. By comparison with the escarpment-top gulls and those in the Naunton area, they are likely to have infills of blocks or rubble of limestone overlain by deeper soils than the surrounding undisturbed ground.

6 QUATERNARY

In many parts of the north Cotswolds, brown quartz and quartzite ('Bunter') pebbles are found on the plateau (Lucy, 1872; Gray, 1911; Dines, 1928; Richardson, 1929, pp. 133-135; Sumbler et al., in press), most commonly singly, and may include the last remnants of once-extensive early Pleistocene deposits ('Northern Drift'). None were noted during the present survey of the Temple Guiting area.

6.1 Alluvium

The alluvial deposits in this area comprise grey-brown loamy clay, with dark organic (peaty) layers in places, and lenses and a basal lag of limestone gravel. Tracts of alluvium up to 40 m across flank the River Windrush and Castlett Stream. The deposits may attain 3 m in thickness.

6.2 Head

Many of the dry or seasonally wet valleys in the Temple Guiting area have accumulations of brown stony clay in the bottom. These may be periglacial solifluction material (head) and include hillwash (colluvium) of more recent origin. This is likely to be true of an accumulation of stony clay lying in a valley north of the Manor House [0800 2603], which hangs over the Castlett Stream.

However, the remainder are likely to be mostly water-lain, and may be regarded as ancient alluvium, deposited by permanent streams when the water table stood higher than at present. These deposits are typically flat-topped, and may be difficult to distinguish from, and grade into modern alluvium, e.g. near Pinnock Warren [0690 2699].

An accumulation of stony, loamy clay spreads onto the floodplain of the Windrush south of Temple Guiting [0955 2730] forming a fan of probable recent alluvial origin.

Part of a more extensive spread of gravel, sand and clay lies in the extreme north-west at Hailes Abbey [050 299]. This is thought to be 'older' head (head gravel on the 1:50 000 scale geological map), resulting from solifluction of material from the escarpment.

None of these deposits is likely to exceed 3 m in thickness.

6.3 Landslip

Landslips result from failure of slopes, normally in non-cohesive materials (e.g. clay or sand), where gravity overcomes the strength of the material or its ability to support itself. Increased loading (e.g. a man-made structure) may generate movement on shear planes, or they may be lubricated by water. The undermining or oversteepening of a slope may also trigger downslope mass movement.

Part of the extensive landslipped area along the slopes of the main Cotswold escarpment lies in the north-west of the Temple Guiting area. It conceals the outcrops of the Charmouth Mudstone, Dyrham, Marlstone Rock and Whitby Mudstone formations almost entirely. The slips are complex, involving a combination of flows and translational and rotational slips, and they are recognised by the disrupted and hummocky topography of the slipped areas. Commonly there is also a distinct scar at the top of the slip. Terraced slopes have developed where rotational and translational slips have taken place, for instance south-east of Little Farmcote [052 284 to 057 281], some of which slope into the hillside ('reverse slopes'). Similar features occur around Farmcote [061 296 to 060 289], some of which are shown on the Ordnance Survey topographic map as 'strip lynchets', suggesting that they may have been enhanced or modified by man. The slips may also incorporate slabs of limestone material from the overlying beds, and these, and the fissures and shears within the clay may permit water movement and cause springs to rise within the landslip areas (see **7.3**).

A minor slip largely of Harford Member material lies on a valley side south-east of Farmcote Wood Farm [0622 2649].

Minor slips and mud flows of Fuller's Earth clay have overridden parts of the Chipping Norton Limestone outcrop near Newtown Brake [0670 2547 and 0705 2545], although they are too small to depict on the map. There is a possible small slip on the Fuller's Earth outcrop to the south-west [0647 2502].

It is possible that older slips in other places that have become degraded and indistinct through natural processes and farming activities may have gone unrecognised.

7 ECONOMIC GEOLOGY

It is not thought that the clay of the Fuller's Earth Formation has been worked in this area. Generally, the formation in the north Cotswolds is not a true (smectite-rich) 'fuller's earth'.

7.1 Limestone

Most of the limestone formations which crop out in the Temple Guiting area have been worked at some time as indicated by the small quarries and degraded pits on their outcrops. The dry stone walls, which are so characteristic of the Cotswolds, are likely to be constructed of stone from the Cleeve Cloud, Scottsquar, Notgrove or Eyford members. Any of the limestone strata may have been used for lime-burning or roadstone.

The Cotswold Hill Stone Company at Cotswold Hill Quarry [081 293] (Locality M) currently (1998) work the Cleeve Cloud Member for sawn and rough building stone.

The fine-grained limestones of the Eyford Member may have been worked for tilestones north-west of Newtown Farm [0680 2579] (Locality D).

7.2 Sand

Although the Harford Member has been dug into in a number of quarries in the area, this is largely a result of exploitation of the adjacent Aston Limestone Formation and Scottsquar and Cleeve Cloud members. However, sand may have been used from a quarry at Pinnock Farm (Appendix 1, Locality N).

7.3 Water supply

In the past, the villages and farms of the Temple Guiting area would have been supplied by springs and wells as detailed for each parish by Richardson (1930, pp. 98, 134 and 160). Richardson (1930, p. 134) claimed that some of the wells and springs were fed from the 'Cotteswold Sands', now known as the Bridport Sand Formation, but it is not thought to be as widely developed as he surmised (see **2.5**) and most of these may be in the basal part of the Birdlip Limestone Formation. All other wells would have drawn from the Inferior Oolite. Most properties are now on mains water, although some local sources may be maintained for emergencies or non-domestic purposes.

During the survey (1996-97), a number of springs were observed in the area, feeding small covered reservoirs, catch wells, ponds, and streams and eventually the rivers. Those not depicted by Ordnance Survey on the 1981 1:10 000-scale topographic map have been added to the geological map (symbolised Spr). A number of these, some of them strong, emerge at or near the base of the Birdlip Limestone Formation along the Windrush and Castlett Stream valleys. Richardson (1930, p. 134) described a pumping scheme from springs at 'Broadwater' on the Castlett Stream [0800 2719 and 0807 2707], and Severn Trent Water continues to pump from here.

The clay beds of the Harford Member are cited (as 'Snowshill Clay') by Richardson (1929, pp. 153-155; 1930, p. 15) as throwing out many springs in the north Cotswolds. He mentions only one in the Temple Guiting area, which feeds a reservoir [0840 2925] at Ford (Richardson, 1929, p. 153). It is not known whether it is still in use. In addition, a weak spring [0648 2662] was observed at the top of the Harford Member south-east of Farmcote Wood Farm during the present survey. A nearby disused hydraulic ram [0653 2662] was probably fed by another spring at this level, now concealed.

At several sites between Farmcote [061 289] and Little Farmcote [051 287], springs arise in the landslip. Here, the water has percolated down through displaced Inferior Oolite limestone blocks, fissures and shears in the slipped and disturbed Whitby Mudstone material and possibly the Bridport Sand Formation (if present, see **2.5**). A spring at Newtown Farm [0700 2547] appears within the Fuller's Earth Formation outcrop, where water is also likely to have passed though fissures and shears in clay.

The water from the limestone formations is likely to be highly calcareous, and minor deposits of lime (tufa) may coat vegetation and stones around the springs.

7.4 Made ground and worked ground

As stated above (chapters 3 and 4), there are numerous small disused pits in the outcrops of the limestone formations. Many are shown as part of the Ordnance Survey topography and where these are wholly or partially filled they are depicted by the Infilled Ground ornament, for instance south of Little Farmcote [050 279 and 050 275], in the northern, disused part of Cotswold Hill Quarry [081 295] and an empty disused quarry nearby [0822 2953].

Many other smaller or largely degraded pits were detected during the present survey. Most probably contain some tipped material, and the larger of these are depicted by the small pit symbol. Others that are completely filled and obscured may remain undetected. The fill materials are largely unknown, but are likely to include hard core, large stone slabs, tree roots and farm and general refuse.

The Worked Ground ornament indicates active or well-defined quarries, such as Cotswold Hill Quarry [081 292]. The limits shown are as at the time of survey (1996-97). These may contain minor areas of fill, spoil heaps or temporary stockpiles.

Dam embankments up to 3 m high have been constructed at Hayles Fruit Farm [0513 2981 and 0522 2955]. There is a large platform constructed by cut and fill at Little Farmcote [0515 2863] and major landscaping has taken place in the extreme north-east at Jackdaw's Castle Racing Stable [0995 2990].

7.5 Engineering hazards

The principal engineering hazards which might occur in this area are unstable natural or artificial slopes, swelling and shrinkage of clays, compressible layers in alluvial deposits and problems with backfilled pits or concealed voids in limestone strata.

Slopes in clay formations (e.g. Charmouth Mudstone, Whitby Mudstone and Fuller's Earth formations) are potentially unstable and, where identifiable landslips have occurred in the past, these are depicted on the map. However, older landslips obscured by later processes (including man's activities) may not have been recognised (see **6.3**). Changes to the conditions, such as loading, steepening and altering drainage, may increase the propensity of a slope to fail.

Clay or clay-rich formations (Charmouth Mudstone, Whitby Mudstone and Fuller's Earth formations) are also subject to swelling and shrinkage, depending on moisture content, which can be affected not only by drainage but also by vegetation, notably trees. This can pose foundation stability problems.

River alluvium commonly includes organic (peat) layers, which may compress under additional loading (e.g. artificial structures).

Limestone formations are prone to potential engineering problems where they have undergone cambering or dissolution (see **5.2**). Here, voids may have formed which may be partially filled with rubble or loose rock, subsequently covered by soil. Surface hollows (gulls) may indicate their presence, or they may be obscured over time and later reappear e.g. because of loading or severe weather (drought or rain).

8 UNPUBLISHED INFORMATION SOURCES

Listed below are the principal items of unpublished data that were utilised during the survey and preparation of Sheet SP 02 NE and this report. Almost all this data is held in BGS archives and is available for consultation. Published data is referred to in the text and listed in References.

8.1 Boreholes

At the time of publication, BGS held records of one borehole sited within Sheet SP 02 NE, the full log is held in the National Geological Records Centre at BGS Keyworth and a summary log appears in Appendix 2. Each borehole record held by BGS is given a unique registration number, in which the borehole logs for each 1:10 000 sheet are numbered consecutively in order of acquisition; thus the full designation is in the form SP 02 NE/1.

8.2 Maps

The following large-scale geological maps cover all or part of Sheet SP 02 NE; these unpublished maps are held in the National Geological Records Centre at BGS Keyworth; they form the basis of the small-scale published 1:63 360 and 1:50 000 scale editions of sheet 217 (Moreton-in-Marsh). Both the manuscript (MS) field maps (with surveyor and date of survey) and the derivative fair-drawn 'standards' (with date of official release) are listed. Some of these maps carry brief notes giving details of exposures etc. Those of the most recent survey effectively supersede the earlier maps.

Glos 20NE/E	H G Dines, 1927, 1:10 560-scale MS field map (partial survey)
Glos 20SE/E	unknown surveyor and date, 1:10 560-scale MS field map (partial survey)
Glos 21NW/W	H G Dines, 1927, 1:10 560-scale MS field map (partial survey)
Glos 21NW/W	unknown surveyor and date, 1:10 560-scale MS field map (partial survey)
Glos 21NW/E	H G Dines, 1927, 1:10 560-scale MS field map (partial survey)
Glos 21NW/E	unknown surveyor and date, 1:10 560-scale MS field map (partial survey)
Glos 21SW/E	H G Dines, 1927, 1:10 560-scale MS field map (partial survey)
Glos 21NW	H G Dines, 1928, 1:10 560-scale MS standard (partial survey)
Glos 21NE	H G Dines, 1928, 1:10 560-scale MS standard (partial survey)
Glos 21SW	H G Dines, 1928, 1:10 560-scale MS standard (partial survey)
SP 02 NE	A J M Barron, 1996-97, 1:10 000-scale MS field map (full survey)
SP 02 NE	A J M Barron, 1998, 1:10 000-scale MS standard (full survey)

8.3 Other documents

BGS Field Notebook record sheets are indexed using a unique two-letter Geologist Code followed by a sequential number:
A J M Barron (Geologist Code BA) (1996-97): Locations BA 44, 57, 68-73, 75-81, 89, 103.

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APPENDIX 1. LOCALITIES

Logged by A J M Barron unless otherwise stated. Field notes that were recorded on BGS Field Notebook record sheets are shown by the unique index in square brackets (see section **8.3**). Other localities described during the current survey were recorded on the MS field map (section **8.2**).

A. [0512 2505] Section in disused quarry, Spoonley Farm [BA 44] (15/4/96)

Strata dip 12° to west-north-west, probably cambered

Birdlip Limestone Formation, Cleeve Cloud Member (c. 1.8)
LIMESTONE, off-white, medium- to coarse-grained ooid grainstone, in slightly irregular medium beds; coarsely shell-fragmental in part, a few burrows — c. 1.8

B. [0593 2510] Section in disused quarry, Roel Hill Farm

Strata dip 2-4° to east.

Aston Limestone Formation, Notgrove Member (c. 3)
LIMESTONE, very pale grey medium- to coarse-grained ooid grainstone in uneven thin to medium beds — c. 3

C. [0574 2621] Hawling Track Quarry, now obscured

Paraphrased and metricated from Richardson (1904, p. 120; 1929, p. 55)

Salperton Limestone Formation, Upper Trigonia Grit Member (0.69)
LIMESTONE, grey, shelly, rubbly with terebratulids, trigoniids and bivalves — 0.69
Aston Limestone Formation, Notgrove Member (1.8)
LIMESTONE, whitish, ooidal grainstone; top bed intensely bored and encrusted with oysters — 1.8

D. [0680 2579] Section in disused quarry, Newtown Farm

Fuller's Earth Formation, Eyford Member (1.0)
LIMESTONE, pale grey-brown, fine-grained ooidal, shell-detrital; platy to medium bedded — 1.0
Fuller's Earth Formation
MUDSTONE spoil, grey, silty; dug from at least 4 m below ground level

E. [0760 2552] Newtown Quarry [BA 57] (1/11/96)

Strata dip 5° to south-west.

Salperton Limestone Formation, Upper Trigonia Grit Member (c. 0.5)
LIMESTONE, grey-brown, shelly, very coarsely shell-detrital packstone/grainstone with abundant fine- to medium-grained ferruginous pellets, common burrows and bivalves, in thin to medium irregular beds; sharp base — c. 0.5
Aston Limestone Formation, Notgrove Member (1.9)
LIMESTONE, pale grey medium-grained ooid and peloid grainstone in medium to thick beds, scattered coarse shell debris, common in top bed; uneven, worn-looking (karstified?) top (not bored or encrusted) — 1.9

Richardson (1929, p. 55) reported 13 feet (4.0 m) of Notgrove Freestone (Member) formerly exposed here.

F. [0535 2692] Straits (Farmcott Wood) Quarry [BA 70] (9/5/97)

Strata dip 7° to south-east.

Salperton Limestone Formation, Upper Trigonia Grit Member (1.8)	
LIMESTONE, mid grey, very shelly, medium- to very-coarsely shell-detrital packstone/wackestone with common ferruginous pellets; very rubbly at top passing down into rubbly-bedded, less shelly limestone; very sharp base	1.8
Aston Limestone Formation, Notgrove Member (0.8)	
LIMESTONE, mid grey, medium- to coarse-grained ooid and peloid grainstone; extremely hard top, bored to 0.05 down; becoming softer downwards	0.8

Buckman (1901, p. 130) reported 14 ft 9in (4.5 m) of Notgrove Freestone (Member) formerly exposed here, with cross bedding.

G. [0530 2703] Straits Quarry (9/5/97)

MADE GROUND with grey clay	0.4
Aston Limestone Formation, Notgrove Member (1.8)	
LIMESTONE, pale grey and yellow-grey, medium-grained ooid and peloid grainstone; cross-bedded to south at top, thin, planar bedded below	1.8

In the quarry floor nearby is a large open joint trending 170° (parallel to the escarpment edge).

H. [0617 2745] Crab Bottom Quarry [BA 69] (8/5/97)

Strata dip 3-5° to south.

Birdlip Limestone Formation, Cleeve Cloud Member (c. 9)	
LIMESTONE, off-white to pale yellow, medium- to coarse-grained ooid grainstone, slightly shell-detrital in parts, some well burrowed horizons, planar thin- to medium-bedded; cross-bedded to south-west at top	c. 9

J. [0597 2787] Section near Lynes Barn [BA 78] (21/8/97)

Strata dip 20° to south-west.

Birdlip Limestone Formation, Leckhampton Member (c. 1.2)	
LIMESTONE, pale orange-grey, fine- to medium-grained shell-detrital, fine- to medium-grained ooidal and peloidal, peloids ferruginous/coated sand grains, thin-bedded, scattered large shell fragments; section cambered	c. 1.2

K. [0510 2794] Disused quarry south of Little Farmcote [BA 75] (18/8/97)

Strata dip 3° to south-east.

Birdlip Limestone Formation, Cleeve Cloud Member (c. 2.6)	
LIMESTONE, off-white to pale grey, medium- to coarse-grained ooid grainstone, thin-bedded, moderately shell-detrital in parts; well jointed	c. 2.6

L. [0663 2851] Disused quarry off Campden Lane [BA 79] (22/8/97)

Strata dip 5° to south.

Limestone rubble, off-white, ooidal	c. 0.5
Birdlip Limestone Formation, Scottsquar Member (0.5)	
MARL/MARLY LIMESTONE, cream to pale brown, coarsely ooidal, very friable, rare small brachiopods, common large shell fragments	0.5
Birdlip Limestone Formation, Scottsquar/Cleeve Cloud Member (3.5)	
LIMESTONE, off-white to pale yellow, medium- to coarse-grained ooid grainstone with wisps and lenses of fine-grained ooids and coarse shell debris, thin-bedded and cross bedded to south and south-west at top, medium-bedded below	3.5

M. [0700 2858] Pinnock Quarry, now obscured

Paraphrased and metricated from Richardson (1929, p. 56)

Birdlip Limestone Formation, Harford Member (2.3)	
CLAY ('Snowshill Clay')	0.9
MARL, cream, clayey	0.41
SANDSTONE, hard	0.56
LIMESTONE, marly, ooidal, ironshot	0.35
Birdlip Limestone Formation, Scottsquar Member (1.0)	
LIMESTONE, cream, with terebratulids and bivalves	0.23
MARL and LIMESTONE, white and cream	0.15
LIMESTONE, cream	0.61

N. [0721 2809] Pinnock Farm Quarry

Paraphrased and metricated from Buckman (1901, p. 133)

Birdlip Limestone Formation, Harford Member (1.7)	
CLAY	seen
SAND, white	1.5
Calcareous layer	0.05
MARL	0.15
Birdlip Limestone Formation, Scottsquar Member (3.0)	
LIMESTONE	1.2
Interbedded white calcareous SAND and LIMESTONE	1.8

Currently (1997) the following is exposed:

Birdlip Limestone Formation, Scottsquar Member (1.7)	
LIMESTONE, pale grey and cream fine- to coarse-grained ooid grainstone, thin bedded; dip 5° to east	1.7

O. [0535 2912] Section in orchard south of Hayles Fruit Farm (1997)

Section in landslipped area, probably not in situ.

Dyrham Formation (c. 0.35)	
SANDSTONE, brownish grey, calcareous, medium-grained, micaceous, with scattered bivalve fragments, including *Protocardia* and *Unicardium?*; thin, uneven bedding; orange-brown weathering	c. 0.35

P. [0629 2994] Bank section north of North Farmcote (1997)

Strata dip 15° to north-west (cambered).

Birdlip Limestone Formation, Leckhampton Member (c. 5)
SANDSTONE, pale grey, calcareous, medium-grained, with ferruginous silt-filled burrows; medium-bedded; cavernous and orange-brown weathering c. 5

Q. [0772 2811] Bank section near Pinnock Farm [BA 72] (14/5/97)

Slight dip to south.

Birdlip Limestone Formation, Leckhampton Member (2.6)
LIMESTONE, orange-brown and grey, extremely sandy, with abundant ferruginous peloids, scattered large shell fragments; rubbly thin beds 2.6

R. [0801 2670] Bank section near Castlett Wood (1997)

Strata dip 8° to north.

Birdlip Limestone Formation, Leckhampton Member (c. 6)
LIMESTONE, pale orange, slightly shell-detrital, sandy, common fine-grained peloids, thin bedded, disturbed c. 6

S. [0843 2587] Section along the 'White Way', near Castlett Wood [BA 71] (12/5/97)

Strata dip 5-12° to north.

Birdlip Limestone Formation, Leckhampton Member (c. 5)
LIMESTONE, orange-brown and grey, finely shell-detrital, finely sandy, common fine-grained ferruginous peloids, rubbly bedded, weathered c. 5

See also Buckman (1901, p. 150) and Richardson (1929, p. 56).

T. [0897 2500] Temporary section, Manor Farm, Guiting Power [BA 68] (30/4/97)

Strata approximately horizontal.

MADE GROUND and LIMESTONE RUBBLE c. 1.3
Birdlip Limestone Formation, Cleeve Cloud Member (c. 1.7)
LIMESTONE, cream to yellow-grey, medium- to coarse-grained ooid grainstone, slightly shell-detrital, thin- to medium-bedded, well jointed c. 1.7

U. [0819 2921 to 0808 2918] Cotswold Hill Quarry, Ford [BA 89] (6/11/97)

Logged by AJMB and A N Morigi.

Slight dip to south.

Birdlip Limestone Formation, Harford Member (3.85)
19. LIMESTONE, pale grey-brown, finely peloidal and sandy grainstone, with numerous coarse orange peloids floating and concentrated in layers, scattered large shell fragments, a few large muddy burrows c. 0.1
18. LIMESTONE, pale orange-brown, fine- to medium-grained peloid and ooid grainstone, some ferruginous peloids, scattered large shell fragments, a few narrow burrows; poorly exposed at base c. 1.25
17. CLAY, mottled grey and orange-brown, slightly sandy, scattered black carbonaceous flakes 0.35

16. LIMESTONE, mid bluish grey, extremely coarsely shell-fragmental, coarsely peloidal grainstone, uneven platy bedded	0.10
15. CLAY, pale brownish greenish grey, scattered medium to coarse shell fragments and black carbonaceous flakes	0.55
14. SAND, mottled pale grey and orange-brown, medium-grained, very clayey at top with pods of smooth pale grey clay, and rusty staining of sand; passing down into:	c. 0.8
13. CLAY, pale grey; passing down into:	c. 0.45
12. MARL, cream, ooidal	0.25
Birdlip Limestone Formation, Scottsquar Member (c. 7.2)	
11. LIMESTONE, pale grey, medium-grained peloidal wackestone with scattered large shell fragments, unevenly thin-bedded; paler, marly and nodular in lowest 0.2	1.55
10. LIMESTONE, pale grey/mid bluish grey hearted/mottled, medium-grained peloid packstone/wackestone, scattered medium to large shell fragments and small black organic flakes, hard; in four beds with thin brown marly interbeds	1.50
9. CLAY, mottled grey, orange and brown, silty, highly calcareous	0.75
8. LIMESTONE, pale grey, orange mottled, medium peloidal packstone with scattered coarse peloids	0.27
7. MARL, pinkish brown with pale mottles, medium- to coarse-grained peloidal and shell fragmental; orange brown in middle, brownish grey and finer at base; very sharp base	0.21
6. LIMESTONE, pale yellowish grey, poorly sorted fine- to coarse-grained ooid grainstone with numerous coarse-grained coated peloids and shell fragments, scattered very large shell fragments; top very hard and iron-stained; local packstone texture; thins northwards	1.30
5. LIMESTONE, very pale grey with orange mottling, medium-grained peloidal packstone with scattered coarser peloids and scattered valves and whole brachiopods, including *Plectothyris fimbria,* much fine shell debris; rubbly habit; very sharp base	1.62
Birdlip Limestone Formation, Cleeve Cloud Member (21.7-22.1)	
4. LIMESTONE, very pale grey with some pale orange mottling, moderately sorted medium- to coarse-grained ooid grainstone, local packstone texture; no sign of hardground on top; uppermost thick bed shows well-developed cross-bedding	c. 2.5-2.9
3. LIMESTONE, very pale grey with some pale orange mottling, moderately sorted medium- to coarse-grained ooid grainstone, scattered coarse-grained peloids; thick to very thick beds, cross-bedding present in a few beds; well-sorted in parts; poorly sorted fine- to coarse-grained; lower part very pale to deep cream in colour	14.65
2. LIMESTONE, pale cream, moderately sorted medium- to coarse-grained ooid grainstone, many ooids orange cored, intense local burrowing; uneven base	c. 0.15
1. LIMESTONE, pale cream, medium- to coarse-grained ooid grainstone, common coarse-grained shell debris, medium to thick beds; at 1.4 below top, base of bed is very hard with ferruginous cement and very large oyster valves (up to 0.12 across), some articulated; in south of quarry Bed 1 is pale to mid orange-brown, very shell-detrital fine to coarse-grained ooid grainstone	4.4 seen

V. [0896 2822] Bank section, Temple Guiting [BA 81] (26/8/97)

Strata dip 52° to west (cambered).

Birdlip Limestone Formation, Cleeve Cloud Member (1.5)	
LIMESTONE, yellow-brown, coarsely shell-detrital fine- to medium-grained ooid grainstone in thin beds; rubbly at top	1.5
Birdlip Limestone Formation, Leckhampton Member (1.0)	
LIMESTONE, orange-brown, finely shell-detrital, sandy, ferruginous, medium-bedded	1.0

Orange sand dug below (weathered Leckhampton Member).

W. [0914 2748] Temporary section, Temple Guiting [BA 76] (20/8/97)

Strata dip 50° to south-west (cambered).

Birdlip Limestone Formation, Cleeve Cloud Member (c. 3.7)	
LIMESTONE, yellow-grey, shell-detrital fine- to coarse-grained ooid grainstone in steeply dipping and disturbed beds; highly jointed	c. 3.7

X. [050 275] Sudeley Hill 'Dirty Quarry', now obscured

Paraphrased and metricated from Buckman (1901, p. 131) and Richardson (1929, pp. 54-55)

Aston Limestone Formation, Notgrove Member	
Limestone fragments in soil	
Aston Limestone Formation, Gryphite Grit Member	
MARL and LIMESTONE, yellowish, *Gryphaea*	0.46
LIMESTONE, shelly, rubbly, with numerous *Gryphaea* and with *Belemnites gingensis* near the top	0.61
LIMESTONE, sandy, yellowish, hard top, with trigoniids and terebratulids	2.4 seen
OBSCURED	c. 2
Aston Limestone Formation, Lower Trigonia Grit Member	
LIMESTONE, brown-speckled, hard, sandy, with bivalves	0.76 seen

APPENDIX 2. BOREHOLES

SP 02 NE/1 Cotswold Hill Quarry [08089 29302]
Surface level c. +231 m AOD
(Log abbreviated by A J M Barron)

	Thickness (m)	Depth (m)
Cleeve Cloud Member		
LIMESTONE, pale yellow-brown, ooidal, moderately sandy; shell detrital in parts; thin to thick-bedded; some soft beds	5.80	5.80
Cleeve Cloud Member, 'Yellow Guiting Stone'		
LIMESTONE, orange-brown, ooidal, with sand-grain cores; variably ferruginous; shell detrital in parts; thin to thick-bedded and cross-bedded with clayey partings	9.00	14.80
Leckhampton Member (+ Crickley Member?)		
SANDSTONE, calcareous/ LIMESTONE, very sandy, pale grey, shelly in parts, ferruginous near top, patchily decalcified; thin- to medium-bedded	3.00	17.80
SANDSTONE, calcareous/ LIMESTONE, very sandy, pale grey, patchily decalcified; ooidal limestone beds from 21.00 to 21.30 and 22.37 to 22.46	5.70	23.50
Bridport Sand Formation		
SAND, brown, and grey sandstone; shelly at 25.0; to Terminal Depth at	4.00	27.50