BRITISH GEOLOGICAL SURVEY

TECHNICAL REPORT WA/88/27

Onshore Geology Series

TECHNICAL REPORT WA/88/27

Geological notes and local details for 1:10 000 Sheets SP51NW and SW Weston-on-the-Green and Islip

Part of 1:50 000 Sheets 218 (Chipping Norton), 219 (Buckingham), 236 (Witney) and 237 (Thame)

R J Wyatt and K Ambrose

Geographical index
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Subject index
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PREFACE

This account describes the geology of 1:10 000 Sheets SP51NW and SW which cover the country around Weston-on-the-Green and Islip. The area falls within 1:50 000 Sheets 218 (Chipping Norton), 219 (Buckingham), 236 (Witney) and 237 (Thame).

The area was first surveyed on the 'one inch' scale by H Bauerman, E Hull, T R Polwhele and W Whitaker as part of Old Series Sheets 45SW and SE, published in 1859 and 1863 respectively. An account of the geology is given in Green (1864).

The area south of grid northing 16 was resurveyed on the 'six-inch' scale by J H Blake and T I Pocock in 1904-5 as part of the Oxford Special Sheet; a descriptive memoir, 'Geology of the country around Oxford', followed (Pocock and others, 1908). Drift deposits were later added to the six-inch maps by H G Dines in 1936. A 1 km-wide strip at the northern margin of the district was mapped by B J Williams in 1961.

The 1:10 000 revision survey of the area west of grid line 53 was undertaken by J Brewster and K Ambrose in 1975 on a reconnaissance basis only. The remainder was completed by K Ambrose and R J Wyatt in 1986, under the direction of R G Thurrell, Regional Geologist.

Uncoloured dyeline copies of 1:10 000 maps SP51NW and SW can be purchased from the BGS Sales Office at Keyworth. Borehole records can be consulted in the National Geosciences Data Centre, Keyworth.

INTRODUCTION

Much of the area under consideration is occupied by the Oxford Clay outcrop and is characterised by low-lying, subdued relief. Small, flat-topped, elevated tracts in the north-west and south-west are capped by river terrace gravels, and at the northern margin of the district a broad dip slope of Cornbrash is gently inclined to the SSE.

However, the landscape is dominated by the Cumnor Formation escarpment in the south-east, near Elsfield, which reaches 117 m OD in elevation; and by a prominent hill west of Noke. The former is composed of the Beckley Sands and isolated outcrops of Wheatley Limestone; the latter is capped by Middle Jurassic limestones which form the core of the Noke Pericline. This considerably faulted WNW-ENE trending structure is intersected west of Noke by the equally strongly faulted Charlton Anticline, which trends at right angles to it and which is characterised by several small inliers of Cornbrash and Forest Marble limestones.

The River Cherwell meanders across a broad alluvial floodplain, up to 1.8 km in width in the south. It drains the Middle Jurassic limestone plateau to the north of the district and flows southwards into the River Thames. A major tributary, the River Ray, flows westwards from Otmoor (on adjoining Sheet SP51SE) to a confluence with the River Cherwell at Islip. Most of the minor tributaries in the northern part of the area flow into the River Ray.

The villages of Bletchingdon, Weston-on-the-Green and Islip are the principal settlements in a largely agricultural area, but the northern outskirts of Oxford impinge on the south-western corner of the district. Much of the land is devoted to arable and dairy farming, the latter predominating on the Cherwell floodplain. In addition, market gardening is undertaken on the light, warm soils of the Beckley Sands outcrop, near Elsfield.

GEOLOGICAL SEQUENCE

Landslip

DRIFT

- Quaternary
  - Alluvium
  - River Terrace Deposits
  - Head

SOLID

- Jurassic
  - Ancholme Group
    - Kimmeridge Clay Formation
    - Cumnor Formation
      - Wheatley Limestone Member
      - Beckley Sand Member
    - West Walton Formation
    - Oxford Clay Formation
      - Upper, Middle and Lower Oxford Clay members
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      - Kellaways Clay Member
  - Great Oolite Group
    - Cornbrash Formation
    - Forest Marble Formation
    - White Limestone Formation
      - Bladon Member
      - Ardley Member
      - Shipton Member
    - Hampen Marly Formation
    - Taynton Limestone Formation
    - Sharps Hill Formation (Proved in boreholes only)
    - Chipping Norton Limestone Formation (Proved in boreholes only)
  - Inferior Oolite Group (Proved in boreholes only)
    - Clypeus Grit/?Grantham formations (Proved in boreholes only)
  - Lias Group (Proved in boreholes only)
    - Upper Lias (Proved in boreholes only)
    - Middle Lias (Proved in boreholes only)
    - Lower Lias (Proved in boreholes only)
  - Penarth Group (Proved in boreholes only)
  - Upper Old Red Sandstone (Proved in boreholes only)

SOLID FORMATIONS

Devonian

A total of 131.0 m of Devonian strata, mainly of continental facies, was proved in Noke Hill Well [5386 1285], from 116.8 m to the base of the borehole at 247.8 m (Falcon and Kent, 1960). They consist of reddish brown silty mudstones with intermittent beds of greyish green silty mudstone and siltstone. Fish fragments, identified as *Bothriolepis* sp. and *Holoptychius* sp., were obtained between 175.18 and 201.24 m in the well; they indicate an Upper Devonian age. *Lingula* sp. was also collected at three levels, suggesting periodic marine incursions.

Penarth Group

Beds of the Penarth Group have been proved in Noke Hill Well [5386 1285] resting unconformably upon Devonian mudstones. They comprise 6.4 m of pale grey, fine-grained, slightly calcareous sandstones, which are very pebbly at the top. These sandstones represent a marginal facies deposited adjacent to the contemporary London Platform land mass to the south-east. Similar lithologies in boreholes in Buckinghamshire have been named the Twyford Beds (Donovan and others, 1979). It is not known which of the constituent formations of the Penarth Group (Westbury and Lilstock formations) these beds correlate with.

Lias Group

Liassic strata have been penetrated in wells at Bletchingdon [5050 1731] and Noke Hill [5386 1285]. In the former the Upper Lias is represented by 3.3 m of 'blue-brown and mottled clays'. These overlie 12.5 m of 'sand, sandstone and rock' which are taken to represent the Middle Lias and which possibly include strata corresponding to the Marlstone Rock Bed, at the top. At the base of the well 2.4 m of Lower Lias 'clay' were proved.

In Noke Hill Well, 67.1 m of bluish grey clays, assigned to the Lower Lias, include sporadic beds of calcareous siltstone and silty limestone, with ironstone and pyrite nodules at some levels. The presumed absence of the Upper and Middle Lias indicates a major non-sequence at the base of the

Inferior Oolite Group.

Donovan and others (1979) have shown that the history of Liassic sedimentation is one of progressive overlap and thinning onto the London Platform land area. At Twyford, ENE of Bicester, where the Lower Lias thickness is comparable to that at Noke, beds of the Hettangian and Sinemurian stages are missing at the base of the sequence. It is probable that much the same situation exists at Noke.

Inferior Oolite Group

A well at Bletchingdon [5050 1731] proved a sequence, described as 'rock with clay bands', below the Sharp's Hill Formation and overlying the Upper Lias. These beds may include the Chipping Norton Limestone Formation above and the Inferior Oolite below, although they cannot be differentiated. It is inferred that the Inferior Oolite beds belong to the Clypeus Grit Formation which, at outcrop, is mainly characterised by coarse-grained, shelly, pisolitic limestones and marly limestones. Their thickness cannot be estimated from the driller's log.

On the eastern side of the district beds at this level comprise sands, variously described in well records as brown, reddish and black sands, with associated clays. In Noke Hill Well, beds at this stratigraphical level are described as silt, silty mudstone and limestone. The beds could represent a sandy facies of the Chipping Norton Limestone of Bathonian age but, following Horton (1977), they are presumed in this account to correlate with the so-called 'white sands' of the Grantham Formation and possibly the Northampton Sand Formation (Scissum Beds) which, like the Clypeus Grit, are of Bajocian age.

Great Oolite Group

Chipping Norton Limestone Formation

The Chipping Norton Limestone Formation is penetrated in six wells within the district but, where the Sharp's Hill Formation is absent or not recognised in drillers' logs, it is difficult to differentiate from the Taynton Limestone Formation. Furthermore, in the western part of the district, where the

Inferior Oolite Group occurs in a limestone facies, the Chipping Norton Limestone cannot be distinguished from the underlying Clypeus Grit. The only well in which the thickness of the formation can be estimated with any confidence is that at Weston-on-the-Green [5337 1846] where it is about 2.3 m thick.

Drillers' descriptions generally speak of 'hard or soft rock'; chipping samples from Noke Hill Well are described as sandy limestone or calcareous sandstone. Cores from trial boreholes on the adjacent SP51NE sheet revealed cream, fine-grained, compact sandy limestones (Ambrose, 1988a) which are typical of the outcrop further west in Oxfordshire.

Sharp's Hill Formation

In only two wells, at Bletchingdon [5050 1731] and Weston-on-the-Green [5337 1846], can the Sharp's Hill Formation be clearly recognised in drillers' logs; the thickness in both is about 2.2 m. The lithology is described as 'blue clay and soft rock', but cored boreholes drilled nearby on adjacent sheet SP51NE suggest that the beds probably comprise olive silty mudstones and grey shelly mudstones containing abundant oyster shells, with thin bands of argillaceous limestone. In logs of other wells, including the one at Noke Hill, the Sharp's Hill Formation appears to be absent.

Taynton Limestone Formation

There is no outcrop of the Taynton Limestone Formation. It was, however, formerly exposed in the north-east face of the disused Woodeaton Quarry [5341 1230] where Palmer (1973) recorded 0.6 m of sparry shell-fragmental oolite beneath the Hampen Marly Formation. The section is no longer visible, having been obscured by talus.

The formation has been encountered in a few wells, its thickness ranging between 3.2 and 4.9 m. A cored borehole [5711 1715] near Charlton-on-Otmoor on the adjoining SP51NE Sheet, proved 4.4 m of mainly shell-fragmental oolitic limestone, cross-bedded in part, with subordinate fine-grained, muddy, detrital limestones and some olive-coloured calcareous muddy siltstone and mudstone bands (Ambrose, 1988a).

Hampen Marly Formation

The Hampen Marly Formation does not crop out within the district, but it is exposed in the north-east face of the disused Woodeaton Quarry [5338 1233]. Formerly the whole succession, totalling almost 4 m of beds, was visible (Palmer, 1973), but only the top 1.4 m can now be seen. The following is a description of the section, incorporating some of Palmer's observations (his bed numbers are preceded by P):

		Thickness (m)
Bed 5	Marl, rusty brown, finely shell-detrital, with valves of *Liostrea hebridica*	0.15
Bed 4	Clay, pale creamy grey, marly, unbedded, with long vertical rootlets filled with greenish grey clay; darker in basal 0.05 m (Palmer records a number of bivalves)	0.60
Bed 3	Marl, grey, with *L. hebridica*	0.15
Bed 2	Limestone, rusty brown, bluish grey hearted, fine-grained, very sandy, weakly cemented at top and base, with poorly preserved bivalves and scattered carbonaceous plant fragments	0.40
Bed 1 (=P5)	Silt, brown and grey (Palmer records a few vertical rootlets, charaphytes, ostracods and *Cetiosaurus* vertebrae)	0-0.4
Bed P6	Grey clay with vertical rootlets and large logs	2.0-2.4

Taynton Stone below

The Hampen Marly Formation has been proved in a few wells, where dark grey and green clays have been recorded. Thicknesses range between 2.9 and 7.9 m.

White Limestone Formation

The White Limestone Formation crops out principally in two inliers at the summit of Noke Hill [534 124 and 538 128], coinciding with the culmination of the Noke Hill Pericline. There are other small, faulted outcrops at Islip, in the floor of the River Ray valley [5280 1395 and 5270 1385] and in the railway cutting [5254 1423]; and a further one [5221 1481] about 0.5 km NNW of the village.

The outcrops are characterised by a brash of creamy-white micritic and fine detrital, locally oolitic limestones, which are readily distinguished from the coarser, flaggy, shell-fragmental, oolitic limestones of the adjacent

Forest Marble outcrops. The limestones were formerly dug from shallow pits near the Reservoir [538 128], but these are now ploughed over; they were also once penetrated at the base of shallow pits in the Forest Marble limestone outcrop nearby (Arkell, 1944).

A section through the complete White Limestone succession is visible in the faces of the currently disused Woodeaton Quarry [533 123] (for detailed sequence see Appendix; a faunal list is contained within BGS Biostratigraphy Research Group report PD 86/212). The sequence can be divided into the three members which are widely recognisable throughout Oxfordshire (Palmer, 1979; Sumbler, 1984). The lowest of these, the Shipton Member, consists mainly of creamy-white, bioturbated, micritic and finely detrital limestones, with one 0.65 m-thick bed of fine, well-sorted oolite (Bed 6). The bed below the oolite is notable for the occurrence of the alga *Solenopora jurassica* (Palmer, 1979). Bivalves are the commonest fossils throughout, but brachiopods and corals occur at certain levels. The top of the uppermost bed (Bed 8) is generally brown-stained, hard and recrystallised, with marl-filled burrows. This bed is thought to correlate with the regionally significant Excavata Bed (Barker, 1976; Sumbler, 1984) which is commonly recrystallised and locally characterised by a bored hardground top. The diagnostic gastropod *(Aphanoptyxis excavata)* has not been recorded at Woodeaton.

There is a thin brown marl or soft marly limestone bed at the base of the overlying Ardley Member, overlain by a brown, decalcified, fine-grained, detrital, marly limestone containing the casts of numerous bivalve shells - the so-called 'Roach Bed' (Bed 10) (Odling, 1913; Arkell, 1933b). This is succeeded by up to 1.5 m of hard, finely banded, cross-bedded, fine to medium-grained, detrital limestones (Bed 11). The remainder of the Ardley Member consists mostly of creamy-white micritic limestones, including two very fossiliferous beds (Beds 13 and 15). The former (the *Modiolus-Epithyris* Bed of Palmer, 1973) is notable for a great abundance of well-preserved *Epithyris oxonica* in all stages of growth, associated with common *Modiolus imbricatus* and other bivalves. At the southern end of the quarry [5342 1213] this bed passes laterally into a 0.40 m-thick bed of buff and fawn, fine-grained, finely oolitic, detrital, marly, laminated limestone containing laminae of creamy-white micrite. Its brachiopod fauna is represented by scattered *Digonella digonoides*; the bivalve *M. imbricatus* appears to be absent. This lithology and fauna clearly reflects a facies change across the quarry.

Bed 15 may correspond to the *A. ardleyensis* Bed (Sumbler, 1984) although the diagnostic gastropod has not been found. Its rich fauna includes a range of bivalves and numerous epithyrids; one specimen of *D. digonoides* has been collected. The occurrence of *D. digonoides* in Beds 13 and 15 suggests correlation with at least part of the so-called 'Ornithella Beds' of the Cirencester district (Richardson, 1911) of which this brachiopod is characteristic. Above Bed 15 and about 2 m below the top of the Ardley Member there is a 0.5-1.0 m-thick oyster lumachelle composed largely of *Liostrea hebridica* shells in a brown marl matrix.

Beds of the succeeding Bladon Member are exposed in the north-west corner of the quarry only; in the south-west face they have been cut out by the erosional base of the Forest Marble limestones. The basal beds comprise a bluish green unbedded clay with sporadic calcareous 'race' nodules, overlying brown marl containing numerous *L. hebridica* and much carbonaceous plant debris. These sediments together constitute the Fimbriata-Waltoni Beds (Allen and Kaye, 1973). Above these, and preserved beneath the Forest Marble along only a short section of the face, there is up to 0.12 m of cream, rubbly, shelly, burrowed limestone yielding poorly preserved bivalves and gastropods, plus carbonaceous wood fragments. This limestone may represent the base of the Upper Epithyris Bed, the bulk of which is apparently cut out at this locality.

There are difficulties in correlating this succession with that recorded by Palmer (1973). This is partly because the sections he examined have now been quarried away and partly because beds of the Bladon Member were not then visible, having been cut out by the Forest Marble. It is only certain that Palmer's Forest Marble Bed 2, an oyster lumachelle, is Bed 16 of the White Limestone of the present account; and his White Limestone Beds 1-3, 5 and 8-15 correspond to Beds 15, 13 and 1-7 respectively.

A few wells in the district penetrate the White Limestone Formation at depth but, because of the poor quality of drillers' logs, it is difficult to separate it from the limestones of the Forest Marble Formation; thus estimates of thickness are generally speculative. The most reliable estimates are of 12.7 m of 'hard rock' in a well [5337 1846] at Weston-on-the-Green and 8.5 m of 'fine stone' in a well [5334 1731] c 1 km south of the village, adjacent to the A421 Oxford-Bicester road. It is likely that thicknesses vary widely throughout the area as a result of the erosional base of the Forest Marble.

Forest Marble Formation

The most extensive outcrops of the Forest Marble Formation are on the higher ground formed by the Noke Hill Pericline. Small outcrops also occur in the core of the much-faulted Charlton Anticline, north of Noke, and there is a small outcrop about 0.5 km north-west of Bletchingdon Park.

The formation consists of clays and limestones, the latter dominating the lower part of the succession, the former accounting for much of the upper part. Locally, however, limestones directly underlie the Cornbrash at the top and, elsewhere, clays rest on the White Limestone at the base. The clay and limestone facies occur as interdigitating lenticular bodies, characteristic of the Forest Marble Formation throughout Oxfordshire (Sumbler, 1984). A further widespread feature of the formation is its markedly erosional base, which locally, as in part of Woodeaton Quarry [533 123], cuts out the whole of the Bladon Member of the White Limestone.

The clays of the Forest Marble Formation are grey or greenish grey and commonly silty; the occurrence of silt or sand laminae, and calcareous sandstone lenticles, was confirmed in cores from boreholes on adjacent sheet SP51NE (Ambrose, 1988a). Thin lenticular beds of shell-fragmental limestone are present in places. The clays typically weather khaki or orange-brown in colour, and locally contain small calcareous 'race' nodules.

The limestones, as seen in field brash, comprise three main lithologies: i) cream and pale buff, medium-grained, flaggy, abundantly oolitic, shell-fragmental, sparry limestone ii) creamy-grey, medium and coarse-grained, flaggy, sparsely oolitic, shell-fragmental, sparry limestone containing an abundance of comminuted oyster shell debris iii) fawn, fine-grained, compact, sandy tilestone with scattered lignite fragments and strings of mudstone clasts. All three types are commonly cross-bedded.

It is unusual to find entire fossils in the limestones. However, an extensive fauna was collected by Buckland from a quarry at Islip (probably at [523 140] and no longer exposed), and his list of specimens, together with a log of the quarry section, was published by Pocock and others (1908). The list includes fossils which are regarded as diagnostic of the Forest Marble, such as the brachiopods *Dictyothyris coarctata* and *Eudesia cardium.* Arkell (1947) also recorded the section in this quarry, subdividing it into Kemble Beds, Bradford Fossil Bed and Wychwood Beds in ascending order. However, as Sumbler (1984) demonstrates, there is no reliable basis for such a regional subdivision and the terms are no longer used.

The only exposures of the formation at present are in Woodeaton Quarry [533 123] and at Home Farm, nearby. In the quarry the basal 3.5 m of the formation overlie the White Limestone with an erosional channelling base. In the north-west corner of the pit [5317 1233] the Forest Marble beds rest on Bed 24 of the White Limestone, whilst 130 m to the SSE [5324 1225] they overlie Bed 13, having cut out about 4.7 m of beds representing the Bladon Member and the top part of the Ardley Member. The beds consist of 1.2 m of clay with secondary 'race' nodules resting on 2.3 m of cross-bedded, shell-fragmental, oolitic limestone (full details in Appendix).

In the largely overgrown face of a quarry at Home Farm [5310 1217] beds of cream, medium-grained, oolitic, shell-fragmental limestones are thinly interbedded with creamy-grey, coarse-grained, sparsely oolitic, shell-fragmental limestones.

Several wells prove the Forest Marble Formation but, as with the White Limestone, it is difficult to interpret thicknesses accurately from drillers' logs; the range is probably between 7.6 and 14.0m, the greater thicknesses being associated with channelled sequences.

Cornbrash Formation

The Cornbrash Formation has an extensive outcrop at the northern margin of the area where it occupies a broad, gently inclined dip slope. In the southern part of the district it crops out on the flanks of the Noke Hill Pericline and also in small inliers along the axis of the much-faulted Charlton Anticline, north of Noke. There is also a small faulted outcrop near the summit of Noke Hill, preserved in a synclinal flexure.

The Cornbrash gives rise to brown loamy soils commonly containing an abundance of limestone fragments. Two distinctive lithologies have been recognised: i) creamy-grey, fine-grained, poorly fossiliferous, shell-detrital, sparsely oolitic, flaggy limestone and, more commonly, ii) fawn, rusty brown and rubbly-weathering, locally very fossiliferous, finely shell-detrital, bioturbated, micritic limestone which characteristically contains marly partings and burrowfills. The former lithology could once be seen in Noke Quarry [5410 1311], now abandoned and built over, where a total of 1.8 m was recorded by Arkell (1944); the latter yields an abundant fauna of brachiopods and bivalves, of which the brachiopods indicate a Lower Cornbrash (Bathonian) age, comprising the subzones of *Cererithyris intermedia* below and *Ornithella obovata* above.

The zonal ammonite, *Clydoniceras discus,* has been collected from the former Islip Quarry [523 139] where 1.45 m of Cornbrash limestones with marly bands were recorded by Pocock and others (1908). Douglas and Arkell (1932) concluded that there was no representation of the Upper Cornbrash in this district; however Ambrose (1988a) has found evidence to suggest a thin Upper Cornbrash sequence near Murcott on adjoining Sheet SP51NE. The fauna collected during the recent survey is listed in BGS Biostratigraphy Research Group report PD 86/212.

Boreholes throughout the area indicate that the formation thickness ranges from 1.8 to 3.7 m, with an exceptionally thin 0.6 m sequence recorded from a well at Bletchingdon [5050 1731]. Another borehole [5061 1288] proved possibly 4.46 m of Cornbrash, but the lower 1.49 m may be Forest Marble Formation.

Ancholme Group

Kellaways Formation

Kellaways Clay Member

The Kellaways Clay Member crops out around Kirtlington in the north-west corner of the district and occupies a narrow outcrop, mostly 100-200 m wide, trending ENE-WSW from Bletchingdon Park through Weston-on-the-Green. In the southern part of the district it has narrower outcrops, resulting from steeper dips, on the flanks of the Noke Hill Pericline, and also crops out in several discrete faulted patches between Islip Bridge and Oddington, NNE of Noke.

The formation overlies the Cornbrash non-sequentially, the Upper Cornbrash apparently being absent in this area. There are no exposures, but auger samples reveal stiff, dark grey clays and silty clays which give rise to heavy clay soils. The junction between the Cornbrash and the Kellaways Clay on the flanks of anticlinal structures is locally marked by a line of seepages and is readily mapped (e.g. at [542 136]); elsewhere it may be obscurred by stony hillwash derived from the Cornbrash. The passage up into the Kellaways Sand Member is fairly rapid; the boundary between the two members is drawn at the base of the lowest sand horizon.

Borehole data indicate that the Kellaways Clay Member is between 2.0 and 4.4 m thick.

Kellaways Sand Member

The contiguous Kellaways Sand outcrop for the most part parallels that of the Kellaways Clay and is of comparable width. Augering shows that the member consists of yellowish brown clayey silts, silts and fine-grained sands; they are grey in colour where unweathered at depth. Locally, the fine sands were once dug from shallow pits. The sediments are distinct from the clays above and below, and give rise to light sandy and loamy soils. Their thickness ranges from 1.95 to 4.75 m.

Oxford Clay Formation

The Oxford Clay is divided into the Lower, Middle and Upper Oxford Clay members. The Middle and Upper Oxford Clay are present in the south-east of the district only, between Noke and Elsfield, but they have not been separately mapped everywhere. There are no boreholes proving a complete sequence of the formation; thus thickness data are taken from adjacent areas to the east (Ambrose, 1988a, b; Horton, in press) where precise details are known.

The formation is highly weathered to a depth of 2 to 3 m, and commonly slightly weathered down to 5 or 6 m. The profile is characterised by the development of secondary selenite derived from the breakdown of pyrite and calcite. The selenite crystals usually increase in size with depth from fine sand/silt size coating fissures near the surface, to well-formed crystals often several centimetres in length at depth; they die out at 5 to 6 m depth. Race may be common in the uppermost 1 to 2 m. The Lower Oxford Clay has a distinctive weathered profile, usually with sharper boundaries between layers (see below) than those of the Middle and Upper Oxford Clay.

Lower Oxford Clay Member

The greater part of the area is underlain by the Lower Oxford Clay, much of it masked by alluvium and river terrace deposits. Southwards from Weston-on-the-Green, extensive remanié terrace deposits veneer the outcrop, but they are not shown on the map. At the time of survey, there were no exposures of the member apart from a few shallow ditches showing the weathered zone.

The Lower Oxford Clay consists of about 27 m of dark greenish or brownish grey, fossiliferous, fissile, bituminous mudstones. Grey septarian nodules occur at intervals. The fauna is rich and varied, with bivalves, particularly *Nucula,* being most abundant. Also present are ammonites, most commonly of the genus *Kosmoceras,* gastropods, belemnites, crustacea, fossil wood, fish and reptile remains. The serpulid *Genicularia vertebralis* is common in the upper part of the member. Fish debris is usually common in paler mudstones, which have a poor invertebrate fauna. The gastropod *Dicroloma* is abundant at some levels. Shell pavements and ammonite plasters, some pyritic, are common, indicating pauses in sedimentation.

The member shows a distinctive weathered profile, typically as follows:

Pale to medium grey, commonly ochreous-stained, smooth or silty clay	1.5-2.0 m
Chocolate brown, fissile clay with shell traces	c 0.2 m
Dark greenish grey, fissile, fossiliferous mudstone; firm and relatively unweathered	

Ambrose (1988a) recognised five marker horizons in the adjacent area to the east. Only two have been identified within the present district, namely the Wendlebury Nodule Bed and the Acutistriatum Band-Comptoni Bed, respectively 10-11 m and 18 m above the base of the member. In the west of the district, borehole SP51SW/16 [5003 1188] proved a nodule bed 21.8 m above the base of the Member. This is probably the Acutistriatum Band-Comptoni Bed, and indicates a possible westward thickening of the member. The Wendlebury Nodule Bed comprises nodules of hard, splintery, fine-grained limestone with septarian calcite veins. Weathered fragments are commonly subrounded due to solution, with a pale grey, iron-strained surface. The lowest four marker beds in the area to the east are all identical lithologically. Hudson (1978) studied similar nodules at Calvert, noting that they contain only uncrushed fossils. The Acutistriatum Band includes a distinctive nodular, brownish grey, commonly fissile, argillaceous limestone containing crushed ammonites and weathering to more angular fragments. This bed is only locally septarian, for example at Calvert. The underlying Comptoni Bed is a series of cyclic, shelly mudstones with only rare nodule development.

Three boreholes in the west of the district, numbers SP51SW/20 [5072 1327], 29 [5075 1413] and 43 [5083 1382] prove a nodule bed at respectively 2.45 m, 3.4 m and 3.0 m above the base of the member. They correlate with the lowest nodule bed in the area to the east (Merton Nodule Bed of Ambrose, 1988a) and the lowest at Kidlington (Bed 11b of Callomon, 1955). However, the nodule bed in borehole 29 may be the overlying Arncott nodule bed of Ambrose, i.e. bed 16 of Callomon, at Kidlington.

The Wendlebury Nodule Bed has been mapped over short distances in two areas. Around Weston Park Farm [547 183], it forms a good feature and dip slope which become less distinct to the south-west. Nodule fragments occur in the field [542 178] bordering Weston Wood. In the extreme south-east the bed is traceable for a short distance by surface debris, before being cut out by the Merton Fault.

Typical brown-weathering, argillaceous limestone of the Acutistriatum Band occurs on a small dip slope in several places [around 536 165]. Abundant nuculid bivalves are also visible amongst spoil dredged from Gallos Brook and are probably from the underlying Comptoni Bed. The Acutistriatum Band has also been identified to the extreme south-east [545 154].

Beds high in the Lower Oxford Clay crop out around Bletchingdon. Borehole SP51NW/1 [5050 1731] proved about 20 m of Lower Oxford Clay indicating that the Acutistriatum Band crops out around the hill.

Middle Oxford Clay Member

The member has been mapped east of the Stow Lodge fault only, where the conjectural boundaries have been extended from the neighbouring sheet (Horton, in press). The member is also assumed to be present to the west of the same fault, between Woodeaton and the southern edge of the district. A small inlier, which occurs south of Weston-on-the-Green, is fault-bounded to the south-east. The member has not been identified at the surface here but borehole SP51NW/12 [5334 1731] proved 35.1 m of Oxford Clay and Kellaways formations, of which the topmost c 2 m is likely to be Middle Oxford Clay.

The Middle Oxford Clay Member comprises about 22 m of pale to medium grey, smooth to silty, generally poorly fossiliferous mudstone, with subordinate beds of pale grey to buff calcareous siltstone or sandy limestone, particularly in the upper part. At many levels the small bivalve *Bositra buchii* is abundant. Other fossils include the oyster *Gryphaea,* small, pyritised kosmoceratid ammonites, the serpulid *Genicularia vertebralis* in the lowermost beds, and pyritic trails. The junction with the underlying beds is transitional, and in boreholes is taken at the top of the uppermost bituminous bed in the Lower Oxford Clay. The top bed of the Middle Oxford Clay, the Lamberti Limestone, has not been identified.

Upper Oxford Clay Member

The member crops out in the extreme south-east only, in the Drun's Hill-Elsfield area. For the most part, it has not been mapped separately. It consists of about 23 m of smooth, poorly fossiliferous mudstone with thin calcareous siltstones and silty limestones. In the upper part there are thin beds of dark grey, fossiliferous mudstone. The fauna consists mostly of bivalves, including the oyster *Gryphaea dilatata,* pyritised ammonites (mainly cardioceratids) and belemnites. The dark grey mudstones contain only crushed, unpyritised fossils. Pyritic trails occur throughout.

West Walton Formation

The West Walton Formation (West Walton Beds of Gallois and Cox, 1977) is a sequence of argillaceous beds between the Oxford Clay and the Cumnor Formation, which has previously been included in the Oxford Clay. The formation crops out in the extreme south-east around Drun's Hill and on the lower slopes of Lyme Hill, south-west of the Stow Lodge Fault. The outcrop is marked by dark clay soils with a few bored *Gryphaea* and dark grey clay in ditches and auger holes. The base is drawn immediately below a persistent topographical feature.

The West Walton Formation comprises about 15 m of interbedded pale and dark grey, silty mudstones with subordinate siltstones. The dark mudstones predominate in the upper part and typify the formation in this area. They are richly fossiliferous, the fossils being preserved mainly as crushed shells. Downwards, the pale mudstones become more common and are identical to those in the underlying Upper Oxford Clay. They are much less fossiliferous and the fossils are commonly preserved as pyrite casts. The two mudstone types commonly have interburrowed junctions. The base of the formation is taken at the lowest recognisable dark grey mudstone, which is about 1 m thick.

The fauna is dominated by bivalves, and perisphinctid and cardioceratid ammonites. The oyster *Gryphaea dilatata* is common throughout and is usually bored and encrusted with serpulids. These latter features are a useful aid in distinguishing the formation from the underlying Upper Oxford Clay where the oysters are not bored or encrusted. *Chondrites* is common throughout.

The weathered zone of the West Walton Formation commonly contains selenite crystals. Unlike the Lower Oxford Clay, which weathers to a pale grey clay, the darker beds of the West Walton Formation are clearly visible in the weathered zone, thus aiding its recognition in the field.

Cumnor Formation

Beckley Sand Member

The Beckley Sand Member forms the greater part of the Cumnor Formation outcrop in the south-east corner of the district, near Elsfield. Its outcrop is characterised by light sandy soil, with an abundance of coarse-grained, gritty sandstone fragments where beds or doggers of sandrock occur. The sands are yellowish brown, fine to coarse-grained, clean, well sorted and uncemented. Where seen in quarry sections they have been described as planar bedded.

Impersistent, nodular masses or doggers of pale grey or fawn, coarse-grained, gritty, calcareous, quartzose sandstone with large sub-rounded quartz grains occur at several levels; they commonly contain numerous small oyster shell fragments. At the base of the member a persistent bed of similar sandstone contains lignite fragments and some sandy burrowfills. It forms a bold feature littered with large sandstone slabs and smaller flaggy fragments. Prominent load cast structures occur on what is assumed to be the underside of many slabs. A similar feature-forming gritty sandstone bed, about 2 m above, contains many gastropods at [5457 1095]. Springs emerge at the base of both these sandstone beds. Separating them there are fine-grained, clayey, silty sands and silts; these, together with the underlying sandstone bed, are regarded by Horton (in press) as comprising the Temple Cowley Member of the Cumnor Formation.

The thickness of the member is estimated to be 25 m, but thins to about 15 m at Drun's Hill. A well at Forest Farm [5446 1079], commencing near the top of the sequence, passed through 20.5 m mainly of sandstone. The high percentage of sandstone could not have been anticipated from surface indications, and it seems that in the weathered zone much of the cement is leached out to leave loose sand.

Wheatley Limestone Member

The Wheatley Limestone Member crops out in small outliers in the extreme south-east corner of the district, near Elsfield, capping the highest ground of the Cumnor Formation escarpment. Additionally, a faulted outcrop occupies a synclinal flexure at Drun's Hill, where the total thickness of the member is estimated to be about 5 m.

The member, as represented in field brash, consists mainly of pale cream and creamy grey, shell-fragmental, bioturbated, sparry limestone and marly limestone, commonly containing marly burrowfills. Shell material is mainly fragmentary and entire shells are uncommon. Subordinate fragments of white, pale grey and pale fawn, coarsely sandy, gritty, shell-fragmental limestone containing large sub-rounded quartz grains also occur. It is possible that these may derive from the topmost bed of the underlying Beckley Sand Member, but this could not be confirmed from surface indications. Alternatively, this gritty limestone may correspond to the Bottom Hard Band (Bed 4) described by

Callomon (1953) from c 0.5 m above the base of the Wheatley Limestone at Woodperry Road Quarry, Beckley [569 109], about 1 km east of the present area. His basal Shell Pebble Bed (Bed 2) was not recognised in the Elsfield outcrops.

In the former quarry sections at Beckley, the Wheatley Limestone could once be seen to rest unconformably on the Beckley Sand, locally cutting out the topmost levels of the latter. A 15 m fall in the level of the base of the Wheatley Limestone outcrop [c 548 108] just east of Forest Farm may reflect similar downcutting by the Wheatley Limestone; however, it could equally be the result of cambering.

Quarry sections in the Wheatley Limestone at Drun's Hill [5429 1136] and near Elsfield [5452 1056] are no longer visible. About 2 m of well-bedded shelly limestone with marl bands and abundant *Nanogyra nana* shells were recorded at the former, and coralline shelly limestone at the latter (Pocock and others, 1908).

Ampthill Clay Formation

The Ampthill Clay occurs in only one small faulted outcrop [543 113] adjacent to Drun's Hill; it occupies a shallow depression in the core of a synclinal flexure. Dark brown weathered clay can be augered; it gives rise to heavy, tenacious clay soil. Probably no more than the basal 2 m of the formation is present.

There is no evidence of the age of this clay, and its attribution to the Ampthill Clay is tentative. Elsewhere in the district a thin Ampthill Clay separates the Cumnor Formation and the Kimmeridge Clay.

DRIFT DEPOSITS

Head

Significant deposits of Head, accumulated by downslope solifluction of weathered surface material, are confined to small tracts just south-east of Islip Bridge and north-east of Elsfield, and to a larger spread around Lower Wood's Farm, south of Noke.

At the first locality [530 138], near Islip, the valley slope is veneered with a deposit, up to 3 m thick, of orange-brown silt and sand, clayey or pebbly in part, with gravelly bands. An auger hole at [5308 1381] revealed 1.4 m of orange-brown sand, pebbly and clayey at the base, on 0.4 m of bedded clayey sand, on 1.0 m of clayey gravel, becoming sandy towards the base. The gravel element of the deposit derives from weathered Cornbrash upslope.

A lobe of clayey sand, less than 1 m thick, occupies a shallow depression [549 113] on the slope beneath the Cumnor Formation scarp face 700 m north-east of Forest Farm, Elsfield.

A flattish tract on the Oxford Clay outcrop [547 122] between Lower Woods Farm and Woodmoor Copse, which occupies a col between streams draining ENE to Otmoor and WSW to the River Cherwell, is covered by a veneer of Head up to 1 m thick. It consists of yellowish brown clayey silt and gives rise to light loamy soil.

River Terrace Deposits

Fourth Terrace

Deposits of the Fourth Terrace occur at Kirtlington [c 501 195] and Bletchingdon [c 502 176] in the north-west corner of the district. The deposits cap interfluves and rest on benches cut in Oxford Clay at an elevation of c 95 m OD, about 30 m above the R. Cherwell floodplain. Thicknesses of up to 6 m have been recorded at Kirtlington (Sandford, 1924). The sediments consist mainly of poorly sorted, sub-rounded Jurassic limestone gravel, with subordinate Liassic ironstone clasts; there is a small proportion of erratics, chiefly angular flints and 'Bunter' quartzite pebbles. A cesspit section at Bletchingdon [c 502 176], recorded by H G Dines in 1936, revealed 2.1 m of gravelly sand with quartzite pebbles but no limestone fragments, suggesting decalcification in the weathered zone.

The gravels correspond in elevation to those of the Handborough Terrace of the River Thames (Sandford, 1924) which exhibit frost wedge and cryoturbation structures (Kellaway and others, 1971), indicating a cold climate depositional regime. A fauna of temperate vertebrates from this locality is assumed to be reworked from older deposits.

The gravels of the Fourth Terrace are thought to be of early Wolstonian age (Briggs and Gilbertson, 1973, 1980).

Third Terrace

The Third or Wolvecote Terrace (Sandford, 1924) of the rivers Thames and Cherwell occurs in two areas. In the north-east, two outcrops of terrace gravel flank the Gallos Brook at Weston-on-the-Green. The gravel is fine-grained and composed mainly of Jurassic limestone fragments, but there is a small component of angular flints, and pebbles of quartzite and quartzose sandstone. Near Southfield Farm [5285 1900] small ironstone pebbles, probably derived from the Marlstone Rock Bed, are prominent. Extensive flats continue southwards from the village, but only thin pockets of remanié gravel and sandy or gravelly soil are preserved; they have not been mapped. The terrace surface has a gentle southward fall from about 72 m OD at Weston to 64-65 m OD at its most southerly limit around Barndon Farm [536 161].

The Third Terrace also occurs in the south-west corner of the district, on the outskirts of Oxford. Here the terrace surface is at c 70 m OD, some 12 m above the Cherwell floodplain. Up to 2.5 m of bedded sand and gravel, in part ferruginous, were recorded by Sandford (1924) at Davenport Road [c 502 100]. Sandford also described a channel fill sequence (Wolvercote Channel) in a gravel pit about 700 m to the north-west [498 105]. Although just outside the present area, it may well extend eastwards onto Sheet SP51SW. The channel, which cuts through the terrace gravel into the Oxford Clay, is floored by about 1.5 m of sand and gravel with iron-pan layers, pocketed into bedrock. Vertebrate remains and Acheulian flint implements have been collected from these deposits. They are overlain by up to 4.3 m of very silty laminated clay representing a phase of ponded, quiet water deposition. The sequence is completed by a 1.5 m thick layer of cryoturbated brown sand, pocketed into the underlying clay; Sandford considered this to be a solifluction deposit.

The deposits of the Third (Wolvercote) Terrace are regarded as of mid Wolstonian age (Goudie and Hart, 1975).

Second Terrace

The Second Terrace of the R. Cherwell, i.e. the Summertown-Radley Terrace of Sandford (1924), only just impinges on the southern margin of the sheet area at [521 100]. It is part of a gravel spread which extends south-eastwards to Marston [527 088] on the adjacent map. The gravels are divisible into upper and lower parts (Sandford, 1924), locally with intervening shelly sands containing *Hippopotamus* which is characteristically associated with Ipswichian inter-glacial deposits. Thus the lower gravels are regarded as of late Wolstonian age and the upper gravels as of early Devensian date (Goudie and Hart, 1975).

A small patch of fine, clayey, limestone gravel caps a flattened hill top [541 147] about 1.5 km ENE of Islip; the deposit probably does not exceed 1.5 m in thickness. Arkell (1944) noted the presence of much oyster shell debris in the gravel. Another small, thin deposit caps a similar low hill [548 156] 1 km to the north-east. Yellowish brown sandy silt was augered in a ditch, but the slightly stony soil hereabouts indicates a small gravel component. Both deposits are in the order of 3 m above the R. Ray floodplain and are assigned to the Second Terrace.

First Terrace

First Terrace deposits are mainly confined to the lower reaches of the Gallos Brook, north-east of Islip, where they occupy an extensive flat tract traversed by the stream, for the most part with no alluvial floodplain. The deposits are up to about 1.5 m thick and consist of fine-grained, clean, Jurassic limestone gravel and gravelly sand. A drain section [5340 1526] showed 0.4 m of gravelly soil, on 0.4 m of gravelly sand, overlying 0.3 m of limestone gravel, resting on Oxford Clay bedrock.

The gravels abruptly terminate the Alluvium of the Gallos Brook at [532 159], NNE of Chipping Farm, suggesting perhaps that the brook abandoned its southern course for a time after deposition of these gravels and, at some more recent date, re-established it.

Other First Terrace deposits occur adjacent to the River Cherwell [514 100] near Oxford, and on the margin of Otmoor at Noke. The latter is a silty to sandy clay and clayey sand overlying a thin limestone gravel.

Alluvium

Extensive alluvial deposits occur throughout the area, dominated by those of the Cherwell flood plain in the south-west, which is up to 1.8 km wide. In the north and east, a network of tributaries, which includes Gallos Brook and the River Ray, feed into the Cherwell through a narrow gorge at Islip, cut in the White Limestone Formation. Upstream, the alluvium broadens out on the Oxford Clay. The River Ray drains the basin to the east, which just impinges on to the district at Noke. Immediately south of Woodeaton, the Woodeaton Gap links Otmoor with the River Cherwell and may have acted as an outlet for water. However, the alluvium and underlying gravel are not continuous through the gap.

The alluvial deposits of the Cherwell Valley have been proved in a number of boreholes and trial pits south-east of and parallel to the A43 Oxford-Bicester road. They prove thicknesses ranging from c 1.3 to 3.45 m. The deposit in the boreholes show a predominantly two-fold subdivision: an upper grey, mottled yellow to orange-brown clay which is variably silty to sandy, and locally pebbly, 0.6-2.0 m thick (Alluvium), and a lower, poorly sorted sand, pebbly sand or gravel, 0.2-2.5 m thick. The gravel is similar to the higher river terraces, i.e. dominantly local limestone pebbles with a few flints, and probably represents an extension of the First Terrace. The sand and gravel is locally absent, and in some areas the entire alluvial sequence is sand with gravel at the base. Several boreholes record an upward fining of the sand and gravel. In one area [508 138] immediately adjacent to the River Cherwell, 5 boreholes and trial pits all proved a dark grey to black, locally shelly, organic layer varying from 0.10-1.4 m thick. Two of the borehole logs record the bed as peat, while the remainder describe it as peaty or organic silt and silty clay. Similar alluvial deposits of comparable thickness occur in the tributary valleys of the Cherwell.

Cooper (1961) and Marker & Cooper (1961) argued that there is no alluvium on Otmoor. This has been disproved and some 1-2 m of Flandrian sediments are now known to cover the entire area (Ambrose, 1988a; Horton, in press). They consist of grey alluvial clay with a little sand, which in places overlies a thin, impersistent lag deposit consisting of very small limestone and flint pebbles, fragments of race and *Gryphaea* shells. The myths of peat bogs on the moor were ended by Cooper (1961) and Marker & Cooper (1961); their conclusions were confirmed during the recent survey, but traces of humic or peaty deposits occur locally in the upper 0.5 m.

Landslip

A small area of landslip [around 547 111] 350 m north-east of Forest Farm is composed of Beckley Sand overlain by two small patches of Wheatley Limestone. The latter occur at a much lower elevation than the main outcrop and are, in part, juxtaposed with the Oxford Clay. On the Oxford Special Sheet (1908) this outcrop is interpreted as a graben-like, down-faulted mass. However, it is more satisfactorily explained as strata landslipped on the steep scarp face formed by the Cumnor Formation, perhaps from a cambered lobe. Landslips are more extensively developed to the east, as shown on Sheet SP51SE.

STRUCTURE

Much of the area is structurally simple, with gentle south-east to easterly dipping rocks, locally disturbed by faults. The Weston Fault is the most significant of these, having an estimated downthrow to the north-west of about 20 m. The position of the fault is conjectural, but it must lie between the outcrop of the Acutistriatum Band and borehole SP51NW/12 [5334 1731], which probably commenced in the Middle Oxford Clay.

In the east of the district, between Islip and Woodeaton, two major structural belts converge. The first comprises the north-east - south-west trending Charlton Anticline (Arkell, 1944) and the complementary Wendlebury Syncline (Ambrose, 1988a); the second is the north-west - south-east trending fault and fold belt referred to by Arkell (1947) as the Wheatley fault zone. The two intersect at Noke Hill, forming a periclinal dome in the centre of which the oldest rocks, the White Limestone Formation, crop out (Figure 1). The dome is asymmetrical, with the steepest dips of 7°-10° on the western and southern flanks, and gentler 3°-4° dips on the northern and eastern limbs. Arkell (1944, 1947) described the structure of the area in some detail.

The Charlton Anticline is traversed by a series of small sinistral wrench faults, their trend varying from E-W to SE-NW, which have fragmented the

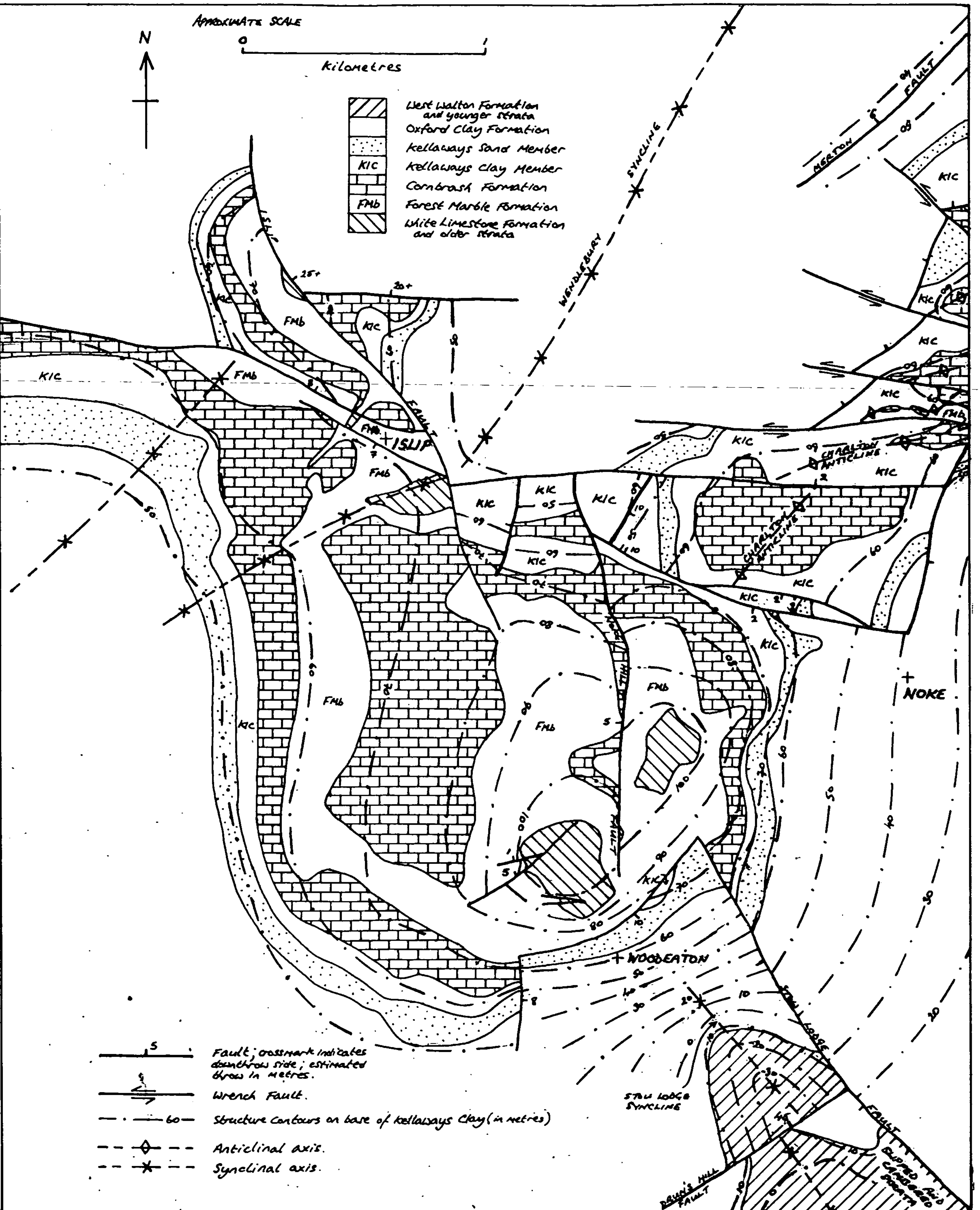

Fig. 1 The structural features of the Noke periclinal dome and surrounding areas.

structure into a series of small periclinal blocks, disposed en echelon. Within these fault blocks, the anticlinal axis trends roughly ENE-WSW. Normal faults, including the Merton Fault, bound the structure, but their continuity at the surface cannot everywhere be demonstrated owing to a widespread covering of river deposits and the absence of reliable markers in the Lower Oxford Clay. Arkell (1933a, 1936) speculated that the anticline extended up to 100 miles but, within the district, there is no evidence of its continuity to the south-west of Noke Hill where it becomes obscured by alluvium. The Wendlebury Syncline continues for a short distance beyond the Wheatley fault zone, where it is displaced up to 1 km to the north-west (Figure 1). North-east of Noke Hill the structure of the Charlton Anticline has been elucidated with the aid of an EM31 conductivity meter, which has helped identify the Kellaways Sand and Cornbrash outcrops beneath alluvium. Details of the methodology are given in Ambrose (1988a).

The Wheatley fault zone is represented by three faults which are disposed en echelon, namely the Islip, Noke Hill (Arkell, 1944) and Stow Lodge (Arkell, 1942) faults. They mark the known northern limit of a 12 mile-long structural belt extending south-eastwards to Great Haseley and Great Milton (Arkell, 1947). The Stow Lodge Syncline (Arkell, 1942), which runs parallel to the Stow Lodge Fault, plunges south-eastwards at about 7° and has limbs dipping at up to 9° north of Drun's Hill Fault. This fault displaces the strata by up to 45 m to the north-west and may continue some distance beyond the mapped limit. The fault apparently displaces the syncline but, because of cambering of the beds in the south-east, the position of the structure contours is only approximate.

Near the summit of Noke Hill there is a small synclinal flexure on the downthrow side of Noke Hill Fault, with Kellaways Clay in the core. The strata on either side of Islip Fault are arched up into an anticlinal structure, but this may be more the result of the faulting than of primary folding.

Arkell (1947) advocated a Lower Cretaceous age for the Wheatley fault zone, and postulated a Tertiary age for the Charlton Anticline (Arkell, 1933a).

HYDROGEOLOGY

The water supply of Oxfordshire has been described by Tiddeman (1910). The main sources of water in the district are the Cumnor Formation limestones and sandstones, the Great Oolite Group limestones and small perched water tables in terrace gravels. At greater depths, the 'Upper Estuarine' sand, Grantham Formation, Marlstone Rock Bed and Middle Lias are also useful aquifers. A good yield from the Great Oolite is not guaranteed owing to the presence of common clay beds. The water can also be saline at distance from the outcrop. Other permeable beds include the Cornbrash and Kellaways Sand, but the water from these tends to be of poor quality. The clay formations yield very little water, which is usually saline.

Springs are common at the base of the Beckley Sand Member and locally occur at the base of the Kellaways Sand and Cornbrash.

ECONOMIC GEOLOGY

Limestone

A number of disused limestone pits are scattered across the area, formerly working Wheatley Limestone, Cornbrash, Forest Marble and White Limestone. They were dug both for building stone and aggregate. The largest quarry, in the White Limestone at Woodeaton, was worked exclusively for aggregate.

Sand and Gravel

Thin spreads of terrace deposits provide a local source of sand and gravel which may have been worked in places on a small scale. Shallow pits in the Beckley Sand may also have been exploited.

Brick Clay

The Lower Oxford Clay is one of the major resources of brick clay, but there are no known workings in the district.

ENGINEERING HAZARDS

This section is intended as a summary of the principal geological hazards identified in the area at the last date of survey. It is not exhaustive and should not, under any circumstances, be used in place of an appropriate geotechnical investigation where development is anticipated.

Landslips, Slopes and Cambering

Only one area of landslip has been identified [around 547 111]. However, moderate to steep slopes encircle Noke Hill, and occur in the extreme south-east around Drun's Hill, Lyme Hill and Elsfield. The slope angles are typically between 4 and 6°, but locally [549 108] they are between 12° and 26°. The western slopes of Noke Hill are only about 2°.

Erosion and modern farming techniques may have destroyed the surface features which characterised landslips that are now unidentified; and drainage works may have stabilised them. The most likely areas for stabilised slips are in the south-east where the Beckley Sands rest on clays of the West Walton Formation. Seepages at the base of the sand provide ideal conditions for the generation of landslips and the geological conditions are analogous to the Panshill area to the east-north-east where both active and stabilised landslips have been identified (Ambrose, 1988b; Horton, in press). The slips can be reactivated when subjected to renewed stresses such as are caused by loading, excavation, or the introduction of water into the slope. Many of the trial pits dug up to 5 m into the stable ground on Panshill collapsed within hours or a few days.

Weathered clay commonly contains small shear surfaces and can be unstable even on gentle slopes.

Cambering with its associated 'dip-and-fault' and 'gull' structures occurs in the Wheatley Limestone and Beckley Sands in the south-east of the district. Such features may also give rise to unstable conditions under abnormal stress.

Head

Head mapped in the area consists of sands and silts, locally clayey, and some gravel. The deposit is unconsolidated and thus poses a geological hazard when subjected to stress, either by loading or by excavations dug into it. Water commonly flows along the base of Head deposits and can act as a lubricant generating a basal slip plane. Small shear surfaces may also be present within clayey Head.

The mapped boundaries of Head shown on the map are only approximate; local, unmapped, thin veneers of the deposit may be present. These could pose problems and should be anticipated where surface developments are being planned.

Alluvium

Like head, alluvium is an unconsolidated deposit. It is composed dominantly of clay and may contain layers or lenses of peat. Both clay and peat are liable to subside when loaded, as a result of compaction. Small shear surfaces may be present, particularly in soft alluvial clays. Such features were noted in thin, unmapped alluvial clays in the Murcott area (Ambrose, 1988a) to the west, where they were exposed in trial pits excavated for the M40 Site Investigation.

Man-Made Deposits

Man-made deposits represent a hazard in three main ways:

(i) The commonly uncompacted or poorly compacted nature of man-made deposits can give rise to unstable foundations. The composition can be very variable from site to site and within short distances on a single site. In places it may be very weak or cavernous and cause excessive and uneven settlement. Organic material within made ground may rot, causing cavitation and settlement below buildings. When spoil is dumped on a slope, the buried soil/organic layer may be weak and therefore might form a potential failure surface. Poorly controlled groundwater flow can produce catastrophic failure of poorly compacted embankments and spoil heaps.

(ii) Toxic residues, either as a primary component of the man-made deposit or generated secondarily by chemical or biological reactions, can migrate both within a deposit itself, and into adjacent permeable strata.

(iii) Toxic or explosive gases, particularly methane, can be generated within waste tips, landfill sites and in disused mine workings. Such gases can migrate - sometimes through adjacent permeable strata - and accumulate within buildings or excavations either nearby or some distance away (cf. Aitkenhead and Williams, 1987).

These possibilities should be addressed by appropriate geotechnical investigations in areas where man-made deposits are likely to be present. The man-made deposits shown on sheets SP51NW and SP51SW represent those that were identifiable at the time of survey.

APPENDIX

Composite section in Woodeaton Quarry [533 123], as recorded in June 1986 (Fig. 2) (see Biostratigraphy Research Group internal report PD 86/212 for full faunal list).

Forest Marble

Bed No.		Thickness (m)
2	Clay, grey and brown mottled, with calcareous 'race' nodules	1.2
1	Limestone, fawn, flaggy, cross-bedded, oolitic, shell-fragmental, sparry, with angular fragments of white micritic limestone locally at base	2.3

White Limestone (Bladon Member)

24	Limestone, cream and buff, finely detrital or micritic, with greenish grey clay-filled burrows, brown carbonaceous wood fragments and poorly preserved bivalves and gastropods	0-0.12
23	Clay, bluish green, with calcareous 'race' nodules near base	0.40-0.60
22	Marl, brown, with sand-grade carbonate detritus; carbonaceous debris and, near base, shell fragments	0.10-0.20
21	Marl, fawn-grey, rusty-mottled, with abundant valves of *Liostrea hebridica* and much carbonaceous plant debris	0.20-0.40

White Limestone (Ardley Member)

20	Limestone, fawn, soft, marly, shell-detrital, slightly oolitic	0.20
19	Limestone, cream, micritic, oolitic, bioturbated	0.70
18	Limestone, cream, soft, marly, micritic, slightly oolitic, bioturbated	0.45
17	Limestone, fawn, hard, bedded, oolitic, detrital, sparry	0.50-0.70

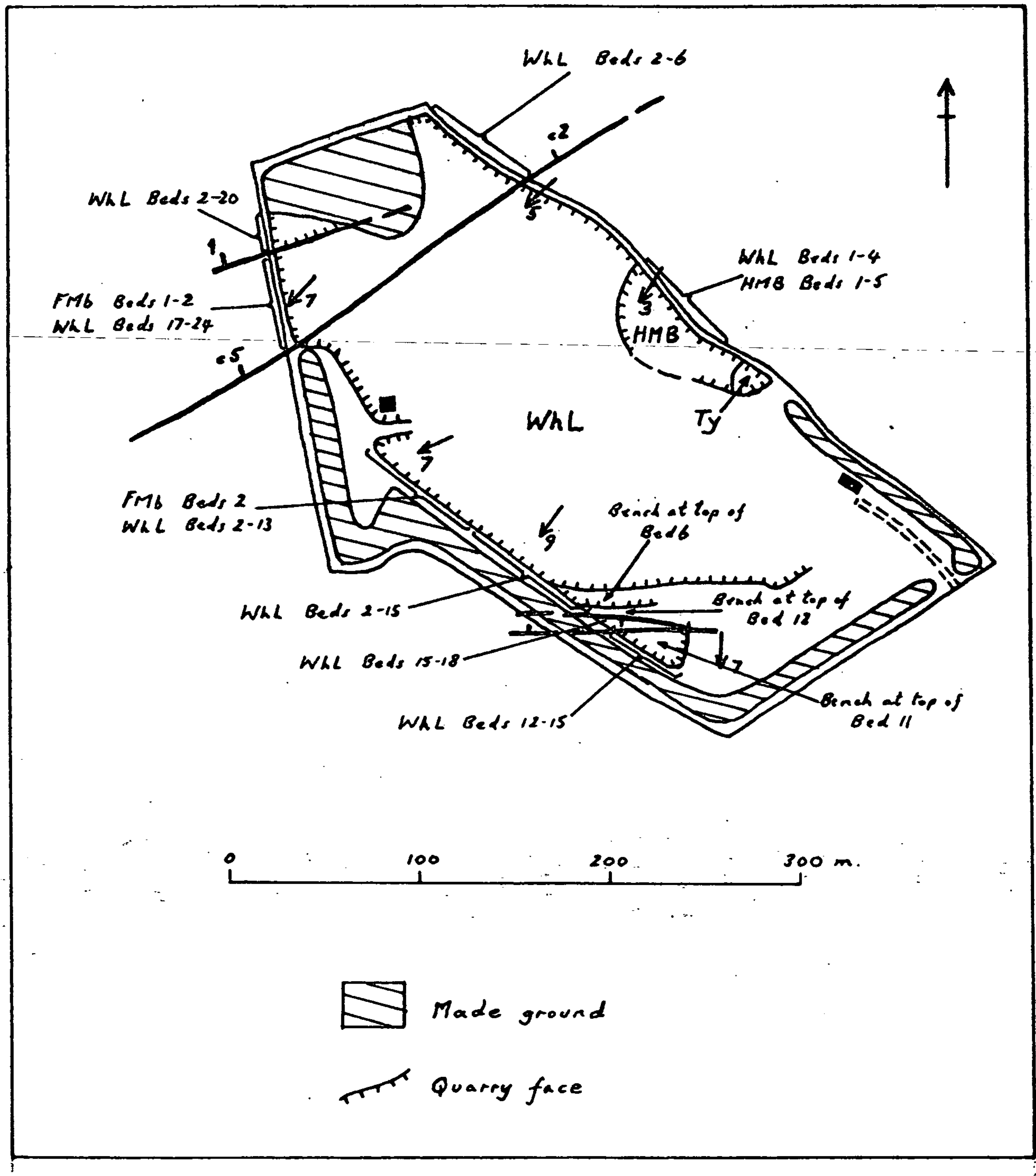

FIG. 2 PLAN OF WOODEATON QUARRY

(as recorded in 1986)

[FMb = Forest Marble : WhL = White Limestone :
HMB = Hampen Marly Formation : Ty = Taynton Limestone]

16	Marly oyster lumachelle, brown, with abundant *L. hebridica*	0.50-1.00
15	Limestone, cream and brown, hard, shell-fragmental, with micritic matrix; very fossiliferous with abundant *Epithyris* and various bivalves; in two beds with a thin marl parting (?Ardleyensis Bed)	0.65-0.75
14	Limestone, creamy white, micritic, patchily shell-detrital	0-1.00
13	Limestone, creamy white, micritic, very fossiliferous with abundant *Epithyris*, *Modiolus* and other bivalves (at southern end of quarry face it passes into 0.40 m of buff or fawn, finely oolitic, fine-grained, detrital, finely banded, tiley-weathering limestone containing laminae of creamy-white micrite, with *Digonella digonoides* and various bivalves)	0.20-0.50
12	Limestone, creamy white, micritic, bioturbated in lower part	0.30-0.50
11	Limestone, creamy brown, fine to medium-grained, detrital, cross-bedded	0.60-1.50
10	Limestone, brown, fine-grained, marly, slightly sandy, with many bivalve casts ('Roach' bed)	0.20-0.25
9	Marl/marly limestone, rusty brown	0.03-0.08

White Limestone (Shipton Member)

8	Limestone, cream, finely detrital, slightly oolitic, with poorly preserved bivalves; top locally brown, hard, recrystallised, with marl-filled burrows; thickest in NW corner of quarry where four beds are separated by thin marly limestones bands (?Excavata Bed)	0.40-1.10
7	Marl/marly limestone, fawn and rusty brown, soft, shell-detrital, oolitic	0.12
6	Oolite, cream, fine-grained, well-sorted	0.60-0.70
5	Limestone, creamy white, finely detrital, rubbly weathering	0.65-0.80
4	Limestone, pale buff, massive, finely detrital,	

	slightly oolitic, with *Thalassinoides* burrows on top surface	0.65-0.80
3	Silt/soft siltstone, fawn, shaly weathering	0.15-0.20
2	Limestone, fawn, finely detrital	1.2
1	Limestone, creamy white, soft, finely detrital	0.40-0.45

REFERENCES

ALLEN, J R L and KAYE, P. 1973. Sedimentary facies of the Forest Marble (Bathonian), Shipton-on-Cherwell Quarry, Oxfordshire. *Geological Magazine,* Vol. 110, 153-163.

AMBROSE, K. 1988a. Geological notes and local details for 1:10 000 sheet SP61NW: Arncott. *British Geological Survey Technical Report* WA/88/22.

AMBROSE, K. 1988b. Geological notes and local details for 1:10 000 sheet SP51NE. *British Geological Survey Technical Report* WA/88/23.

ARKELL, W J. 1933a. *The Jurassic System in Great Britain.* (Oxford: Clarendon Press), 681 pp.

ARKELL, W J. 1933b. The Lower Oolites exposed in the Ardley and Fritwell railway cuttings between Bicester and Banbury, Oxford. *Proceedings of the Geologists' Association,* Vol. 44, 340-354.

ARKELL, W J. 1942. Stratigraphy and structures east of Oxford (Part 1). *Quarterly Journal of the Geological Society of London,* Vol. 98, 187-204.

ARKELL, W J. 1944. Stratigraphy and structures east of Oxford. Part III: Islip. *Quarterly Journal of the Geological Society of London,* Vol. 100, 61-73.

ARKELL, W J. 1947. *The geology of Oxford.* (Oxford: Oxford University Press), 267 pp.

BARKER, M J. 1976. *Gastropods of the Great Oolite.* Unpublished PhD Thesis, University of Keele.

BRIGGS, D J and GILBERTSON, D D. 1973. The age of the Handborough Terrace of the River Evenlode, Oxfordshire. *Proceedings of the Geologists' Association,* Vol. 34, 155-173.

BRIGGS, D J and GILBERTSON, D D. 1980. Quaternary processes and environments in the Upper Thames Valley. *Transactions of the Institute of British Geographers*, Vol. 5, 53-65.

CALLOMON, J H. 1953. Sections in the Corallian Beds at Beckley, Oxfordshire. *Proceedings of the Geologists' Association*, Vol. 64, 83-87.

CALLOMON, J H. 1955. The ammonite succession in the Lower Oxford Clay and Kellaways Beds at Kidlington, Oxfordshire, and the zones of the Callovian Stage. *Philosophical Transactions of the Royal Society of London*, Series B, Vol. 239, 215-263.

COOPER, A D. 1961. *An examination of the landforms of the Ray drainage basin.* Unpublished BSc Thesis, University of Oxford.

DONOVAN, D T, HORTON, A and IVIMEY-COOK. 1979. The transgression of the Lower Lias over the northern flank of the London Platform. *Journal of the Geological Society of London*, Vol. 136, 165-173.

DOUGLAS, J A and ARKELL, W J. 1932. The stratigraphical distribution of the Cornbrash. II The North Eastern Area. *Quarterly Journal of the Geological Society of London*, Vol. 88, 112-170.

FALCON, N L and KENT, P E. 1960. Geological results of petroleum exploration in Britain 1945-1957. *Memoirs of the Geological Society of London*, No. 2, 56 pp.

GALLOIS, R W and COX, B M. 1977. The stratigraphy of the Middle and Upper Oxfordian sediments of Fenland. *Proceedings of the Geologists' Association*, Vol. 88, 207-228.

GOUDIE, A R and HART, M G. 1975. Pleistocene events and forms in the Oxford region. 3-13 in *Oxford and its Region*. Smith, C G and Scargill, D I (editors), Oxford University Press.

HORTON, A. 1977. The age of the Middle Jurassic "White Sands" of north Oxfordshire. *Proceedings of the Geologists' Association*, Vol. 88, 147-162.

HORTON, A. *In press.* Geological notes and local details for 1:10 000 sheet SP51SE: Beckley and Horton. *British Geological Survey Technical Report.*

HUDSON, J D. 1978. Concretions, isotopes and the diagenetic history of the Oxford Clay (Jurassic) of central England. *Sedimentology,* Vol. 25, 339-370.

ODLING, M. 1913. The Bathonian rocks of the Oxford district. *Quarterly Journal of the Geological Society of London,* Vol. 69, 484-513.

PALMER, T J. 1973. Field meeting in the Great Oolite of Oxfordshire. *Proceedings of the Geologists' Association,* Vol. 84, 53-64.

PALMER, T J. 1979. The Hampen Marly and White Limestone Formations: Florida-type carbonate lagoons in the Jurassic of central England. *Palaeontology,* Vol. 22, 189-228.

POCOCK, T I, WOODWARD, H B and LAMPLUGH, G W. 1908. The geology of the country around Oxford. *Memoir Geological Survey, G.B.* 142 pp.

RICHARDSON, L. 1911. On the sections of Forest Marble and Great Oolite on the railway between Cirencester and Chedworth, Gloucestershire. *Proceedings of the Geologists' Association,* Vol. 22, 95-115.

SANDFORD, K S. 1924. The River Gravels of the Oxford District. *Quarterly Journal of the Geological Society of London,* Vol. 80, 113-170.

SUMBLER, M G. 1984. The stratigraphy of the Bathonian White Limestone and Forest Marble Formations of Oxfordshire. *Proceedings of the Geologists' Association,* Vol. 95, 51-64.