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TQ01NW, NE, SW and SE
Pulborough and Storrington

Part of 1:50 000 sheet 317 (Chichester)

Natural Environment Research Council

INSTITUTE OF GEOLOGICAL SCIENCES

Geological Survey of England and Wales

Geological notes and local details for 1:10000 sheets TQ01NW, NE, SW and SE

Pulborough and Storrington

Part of 1:50000 sheet 317 (Chichester)

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with contributions on the palaeontology by
A. A. Mortimer and C. J. Wood

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PREFACE

This report describes the geology of 1:10 000 geological sheets TQ 01 NW, NE SW and SE, which cover the country around Pulborough and Storrington, in Sussex. The area falls within the 1:50 000 Chichester (317) Geological Sheet. It was first surveyed on the 'one-inch' scale by H.W. Bristow and F. Drew as part of Old Series One-inch Geological Sheet 9, published in 1864. The descriptive memoir covering this and adjacent sheets was compiled by W. Topley and published in 1875. The area was resurveyed on the 'six-inch scale by Clement Reid in 1890 and G.W. Lamplugh in 1899-1900, and formed part of the New Series 'One-inch' Geological Sheet 317, published in 1902. A descriptive memoir by Clement Reid appeared in 1903.

Several of the Geological Survey 'Water Supply' memoirs have dealt, in part, with this district, namely: 'The Water Supply of Sussex from underground sources' (Whitaker and Reid, 1899), with a supplement (Whitaker, 1911); 'Wells and Springs of Sussex' (Edmunds, 1928); and 'Records of wells in the Chichester area' (Hargreaves and Parker, 1980).

The 1:10 000 revision survey of the area was carried out by C.R. Bristow in 1979-80 (northern half) and R.J. Wyatt in 1982 (southern half), with the support of the Department of the Environment. This account includes appendices on the fauna of the Pulborough Sandrock by Mr. A.A. Morter and on a Lower Chalk fauna by Mr. C.J. Wood. Mr. D.A. Gray has made available manuscript notes on the hydrogeology of the Chalk/Upper Greensand.

Uncoloured dye-line copies of the 1:10 000 geological sheets can be obtained through the Bookstall, Geological Museum, Exhibition Road, London SW7 2DE.

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1. INTRODUCTION

1.1 Topographical Setting

The area of the present study includes part of the southern margin of the Weald and part of the South Downs chalk escarpment. The landscape is dominated by the latter which reaches a maximum elevation of 213m at Kithurst Hill. Its bold north-facing scarp is diversified by several deep coombes, and the gently undulating dip slope is cut by numerous dry valleys. The thin flinty soils developed on the Chalk are largely given over to arable farming. The escarpment is breached south of Amberley by the River Arun in an impressive gap in which steep river cliffs on the outside of meanders alternate with gently graded slip-off slopes in meander cores.

The remainder of the area displays a diverse landscape in which the well-drained, more elevated outcrops of the Upper Greensand, Folkestone Beds and Hythe Beds contrast with the damp, lower-lying mainly clayey tracts of the Gault, Sandgate Beds and Weald Clay. The Upper Greensand forms an escarpment which, although prominent, is dwarfed by the adjacent Chalk scarp; its rich loamy soils are ideal for arable farming. The light, acid, sandy soils of the Folkestone Beds and Hythe Beds commonly support heathland or woodland, and the outcrops of the clay formations are characterised by permanent pasture.

The district is drained by the rivers Rother and Arun, and their tributaries. The former flows eastwards along the strike of the Lower Greensand and joins the River Arun at Hardham; the latter is a south-flowing consequent river which cuts across the geological grain of the area and flows in large sweeping meanders across a wide floodplain. The large abandoned meander core at Amberley Wild Brooks forms a flat alluvial tract mainly supporting permanent pasture; its northern part is covered by a veneer of peat. A suite of seven river terraces is represented by sandy gravelly flats adjacent to the principal rivers.

Structurally, the area lies on the southern flank of the major Wealden Anticlinorium, the regional southerly dip of which is modified by two folds, namely the Wiggonholt Syncline and the Greenhurst Anticline (Figs. 1 & 2).

1.2 History of Research

One of the earliest researchers into the stratigraphy of the western Weald was Gilbert White (1789) who recognised, in broad outline, the principal formations from the Lower Greensand upwards. Subsequent workers in the early 1800's (Mantell, 1822; Fitton, 1824; Murchison, 1826) elaborated the stratigraphy and recognised the Weald Clay.

In an important memoir devoted to western Sussex, Martin (1828) introduced the following nomenclature, which he modified from that of earlier works: Wealden Sand (Hastings Beds), Weald Clay, Shanklin Sands - subdivided into Lower Greensand (Hythe Beds) below and Ferruginous Sands (Folkestone Beds and Sandgate Beds) above, 'Galt', Malm - subdivided into Malm Rock below and Upper Greensand above, and Lower Chalk. Martin was thus one of the earliest workers to clearly recognise the major subdivisions of the Lower Greensand and to note the occurrences of what came to be known later as the Sandgate Beds and its minor subdivisions. These subdivisions were graphically portrayed by Gould (*in* Topley, 1875, fig. 20) with the ascending sequence of : clayey sand (Fittleworth Beds), sand (Pulborough Sandrock) and shale (Marehill Clay). The last two names were first published by Wooldridge (1928) and Kirkaldy (1933) respectively. These two authors were prominent members of the Weald Research Committee; they and their colleagues published numerous accounts of their researches during the 1930's, including those of Kirkaldy on the Sandgate Beds (1933;

1937) and the base of the Gault (1935a), and those of Gaster (1932) on the zonation of the Chalk. Humphries (1964) studied the Lower Greensand in the western Weald and was able to trace the Marehill Clay and Pulborough Sandrock throughout.

Aspects of the sedimentology have been discussed by several workers: Humphries (1957) considered the origin of the chert in the Hythe Beds; Wood (1957) examined the heavy mineral suites of the Lower Greensand; and Narayan (1963; 1971) and Allen and Narayan (1964) studied the cross-stratification within the Lower Greensand. Casey (1961) reviewed the palaeontology of the whole of the Lower Greensand and provided a reliable zonal framework to which the various formations and members could be assigned. Owen's (1963; 1971; 1975) studies of the Gault and, in part, of the Upper Greensand provide a detailed zonal scheme for these formations. The petrology, conditions of deposition and diagenesis of the Chalk were considered by Hancock (1975) and, more recently, the detailed stratigraphy of the Chalk has been studied by Mortimore (1979; in press).

2. GEOLOGICAL SEQUENCE

The solid formations and drift deposits on 1:10 000 geological sheets TQ 01 NW, NE, SW and SE are listed below:

Superficial Deposits (Drift)

Recent and Pleistocene

- Peat
- Alluvium
- River Terrace Deposits (Terraces 1-7)
- Head
- Clay-with-flints

Solid Formations

Cretaceous

- Upper and Middle Chalk (undivided)
- Lower Chalk
- Upper Greensand
- Gault
- Folkestone Beds
- Sandgate Beds (Marehill Clay
(Pulborough Sandrock
(Fittleworth Beds
- Hythe Beds
- Atherfield Clay
- Weald Clay

3. SOLID FORMATIONS

Within the survey area the solid formations and constituent members exposed at the surface or beneath drift cover are as follows:

		Formation	Member	Thickness m
Cretaceous		Upper and Middle Chalk (undivided)		140+
Cretaceous		Lower Chalk		c 55
Cretaceous		Upper Greensand		c 30
Cretaceous		Gault		c 90
Cretaceous	Lower Greensand	Folkestone Beds		44–71
Cretaceous	Lower Greensand	Sandgate Beds	Marehill Clay	3–11
Cretaceous	Lower Greensand	Sandgate Beds	Pulborough Sandrock	0–10
Cretaceous	Lower Greensand	Sandgate Beds	Fittleworth Beds	10–52
Cretaceous	Lower Greensand	Hythe Beds		33–52
Cretaceous	Lower Greensand	Atherfield Clay		5–10
Cretaceous		Weald Clay		40+

3.1 General Account

3.1.1 Weald Clay

Up to 38m of the Weald Clay crops out in the north-west margin of the district (around 085 200)*, near Woods Hill, and an estimated 10 to 15m in the centre of the Greenhurst Anticline (around 090 157), between West Chiltington and Storrington. It consists of a monotonous series of mottled yellow or orange and grey clays and silty clays. None of the mappable sandstones, limestones and ironstones that are present in the lower part of the Weald Clay

* National Grid References relate to 100 km square TQ throughout unless otherwise stated.

elsewhere occur at outcrop within the present area.

3.1.2 Atherfield Clay

The principal outcrop of the Atherfield Clay is on the northern margin of the district along the main scarp of the Lower Greensand, and beneath the Hythe Beds around the nose of the Greenhurst Anticline. Locally, for example near London Copse (099 195), the outcrop of the Atherfield Clay is cut out by the Hythe Beds which have been cambered across it to rest directly on the Weald Clay.

Where proved in boreholes to the west of the present area, for example in the Hoe's Farm Borehole (SU 9808 1962), the Atherfield Clay consists of silty, greyish brown, shelly mudstone. At the surface it appears as mottled red and grey silty clay, glauconitic sandy clay and brown and grey silty clay. The thickness of this formation varies from 5 to 10m along its northern outcrop.

It is probable that the Atherfield Clay spans the whole of the Deshayesites forbesi Zone of the Lower Aptian Substage (Casey, 1961).

3.1.3 Hythe Beds

The Hythe Beds comprise mainly fine- and medium-grained, pale buff, glauconitic sands and soft sandstones, with sporadic beds of strongly cemented sandstone and bands of doggers. The beds west of the River Arun are dominantly siliceous, with well-developed bands and concretions of chert and cherty sandsone, and with a few calcareous beds.

East of the river calcareous cementation is more common and chert beds are absent.

The Hythe Beds have only a limited outcrop on the west side of the River Arun, where only the upper beds are present. They consist dominantly of fine-grained, glauconitic, locally clayey, sands and sandstones. Cherts, which occur in the lower beds to the north of the present area, are not developed hereabouts.

East of the River Arun, in the area to the north of Nutbourne and West Chiltington, the basal beds are about 20m thick and consist of thinly-bedded, buff, glauconitic, medium-grained sandstone. They are succeeded by sands and sandstones with a calcareous cement which, in weathered sections, give rise to ribs of calcareous sandstone or doggers separated by poorly cemented sands. This lithology is colloquially known as "rag and hassock" and has been compared to the Bargate Beds (Bull and Kirkaldy, 1947). It is difficult to estimate the thickness of this unit, but it appears to be about 20 to 25m. It is overlain by a sequence of buff, glauconitic, fine- to medium-grained sands with some calcareous cement.

Thin seams of fuller's earth have been noted at outcrop in the lower part of the formation. A 0.46m-bed of clay, 11m above the base of the Hythe Beds in a well at Nutbourne, may also be a fuller's earth. On the south side of the Greenhurst Anticline a thin glauconitic sandy clay is developed in the lowest Hythe Beds.

From the width of outcrop the Hythe Beds appear to vary very markedly in thickness. A total of 39m was proved in a borehole at Hardham Pumping Station (0332 1773). In a well at Pulborough (0450 1872), 1km to the north-east, 44.2m of Hythe Beds were penetrated, without reaching the base. This is less than the thickness recorded by Reid (1903, p.10) who included clays which clearly belong to the lower part of the Sandgate Beds. In the area between Broomershill and Smock Alley the outcrop ranges from 1.5km to 2km in width. In this tract boreholes indicate a thickness ranging from 33m to 52m. About 1.5km to the north-east of Smock Alley (around 099 182) the outcrop narrows to 100m, but the dip is steeper (17°) and so the thickness of the Hythe Beds is estimated to be about 40m.

No fauna has been collected from the Hythe Beds of the present district but, from the evidence of the nearby Hoes Farm (SU 9808 1962) and Hurlands Farm (SU 9413 2104) boreholes, the bulk of the formation probably belongs to the Tropaeum bowerbanki Zone, the lowest part being assigned to the Deshayesites deshayesi Zone.

3.1.4 Sandgate Beds

The bulk of the Sandgate Beds consists of glauconitic sandy clays, but at the top of the sequence there are dark silty clays, beneath which fine-grained sands and sandstone ('sandrock') are present over the greater part of the district. Both the clays and the sand or sandrock form well-defined units, and thus the Sandgate Beds can readily be divided into three mappable members, named the Fittleworth Beds, the Pulborough Sandrock and the Marehill Clay in ascending order.

In the Pulborough-Fittleworth area there are passage beds of fine-grained sands, locally containing calcareous sandstone doggers, between the glauconitic sandy clays of the Sandgate Beds and the underlying Hythe Beds. Thus Humphries (1964, p.46) noted a section on Stretch Hill (012 198) where there was 'a gradation upwards from the sandy loams of the Hythe Beds, through pale coloured, poorly graded fine sands showing some bedding (the Bargate Beds), into the brown loams of the Sandgate Beds.' Similar calcareous sands and sandstones with doggers, which are seen elsewhere in the western Weald, e.g. in the Easebourne area near Midhurst, have also been designated Bargate Beds (Thurrell, Worssam and Edmonds, 1968). However, the Bargate Beds of the type area in the north-west Weald, which are characterised by their content of pebbles, ooliths and a prolific fauna, have little in common with them other than their age (Tropaeum subarcticum Subzone of the Upper Aptian Substage). Moreover, Kirkaldy (1937, p.100) has pointed out that east of the River Arun the calcareous sands and sandstones of the passage beds occur at successively lower levels until they finally constitute the greater part of the Lower Greensand below the Sandgate Beds. Thus the term Bargate Beds appears to have been used in an ill-defined manner in this district and there are no grounds on which to differentiate these beds from those below. Accordingly, the term Bargate Beds has not been used in this account.

3.1.4.1 Fittleworth Beds

The strata between the Hythe Beds and Pulborough Sandrock comprise a variable series of glauconitic sandy clays and clayey sands which occupy low-lying gound with few natural exposures. In the past (Drew in Topley, 1875) this unit was commonly referred to simply as 'loams'. However, the informal name Fittleworth Beds was introduced during mapping and has been used in this account.

Augering generally reveals weathered yellowish and orange-brown sandy clays, which give rise to sticky clay soils. Where weathering is less deep, bright green glauconitic sediment is commonly found. These characteristic lithologies can be augered in fields adjacent to the village of Fittleworth, the type locality. At a pit in the village (0143 1954) the beds were formerly worked for brickmaking.

The thickness of the Fittleworth Beds appears to vary markedly along the strike. In the west the width of the outcrop ranges from 300m to 700m and in this tract the thickness is probably between 30m and 52m. At Pulborough the outcrop narrows, beneath Head, to only about 100m; nevertheless, in a borehole (0467 1834) near the church, an incomplete thickness of 47.55m of Fittleworth Beds was proved. Probably the outcrop here coincides with an east-west monoclinal flexure (see Section 4 & Fig. 2) so that the dip is significantly greater than the regional value. Faulting may also be responsible for the reduction in outcrop width in this vicinity because only 24.69m of Fittleworth Beds were encountered in another borehole (0450 1872) only 200m to the south-west. From Nutbourne, where the formation is 45.87m thick (0744 1807), the outcrop widens eastwards to over one kilometre, probably in response to decreasing dip. On the southern flank of the Greenhurst Anticline the thickness is estimated at 25m, although it is probably less in the most southerly outcrop between Parham and Sullington. Only 18.21m were penetrated in the IGS Washington Borehole (1264 1345) just to the east of the present district.

Faunas from the Fittleworth Beds are known from only one locality within the district (0325 1959), near Stopham. The evidence from this and other sites farther west suggests that this member belongs to the Tropaeum subarcticum Subzone of the Parahoplites nutfieldiensis Zone of the Upper Aptian Substage.

3.1.4.2 Pulborough Sandrock

The name of this member was introduced by Wooldridge (1928), the type sections being exposures in the railway (0440 1875) and road (0475 1875) cuttings on the north side of Pulborough.

Throughout its outcrop within the present district the Pulborough Sandrock consists of homogeneous, fine-grained, buff and yellow, well-sorted, locally cross-bedded sands; thin (up to 1 cm) grey clay seams occur in places. Grains of glauconite are present in the lowest beds, near Fittleworth (0040 1940). Apart from local developments of fine-grained sands in the Folkestone Beds, the Pulborough Sandrock is unlikely to be confused with any other member or formation within the Lower Greensand. The upper sands are only weakly cemented but nevertheless are sufficiently resistant to give rise to a distinct low scarp. In places the sandrock forms low crags, but it is exposed most commonly in numerous sunken lanes. A number of quarries have been opened in this member; that at Marehill (0642 1863) was used for moulding sand, and it is probable that the others worked the sandstone for the same purpose as it is too fine-grained to be a good building sand and too friable, apart from its cemented top, to be used as a building stone. The topmost sandrock is usually iron-cemented and varies in thickness between 0.1m and 0.3m.

At Marehill, where the sand was worked in galleries, the ferruginous sandrock forms the cap rock. The lowest beds are uncemented and have been referred to as 'loams' (e.g. Wood, 1957) and generally grouped with the 'loams' of what are now known as the Fittleworth Beds. However, apart from the lack of cement, the 'loams' are very similar to the overlying 'sandrock' and in this account the two are united under the term Pulborough Sandrock.

The thickness of the Pulborough Sandrock is fairly uniform, varying between 8m and 10m. However, in the most southerly outcrop the characteristic scarp feature dies out at Cootham (0760 1462) and, to the east, the member can no longer be recognised as a distinct unit, as the Sandgate Beds below the Marehill Clay are all essentially of Fittleworth Beds facies and cannot therefore be divided.

Wood (1957) has studied the heavy minerals of the Lower Greensand. The suites from the Pulborough Sandrock and Marehill Clay are similar, but can be distinguished from that of the Folkestone Beds by their high percentage of zircon and the virtual absence of kyanite and staurolite. It is interesting to note a decrease in the percentage of zircon and an increase in rutile at the level of the 'sandrock' part of the Pulborough Sandrock (Wood, 1957, fig. 2).

Good molluscan faunas have been found in fossiliferous ironstone nodules at a number of scattered localities throught the western Weald. Although there are many species common to all the localities, there are some which to date are known from only one or two of the sites. The faunas from Parham Park (0535 1525) and Park Lane, Pulborough

(0394 1895) are given in Appendix I. Collectively, the several faunas indicate the Parahoplites cunningtoni Subzone of the P. Nutfieldiensis Zone of the Upper Aptian Substage (Casey, 1961).

3.1.4.3 Marehill Clay

The type locality is the old quarry (0647 1864) at Marehill where the clay was stripped off as overburden during extraction of the sand of the underlying Pulborough Sandrock. Although the presence of the clay has been known since the early decades of the 19th century (Martin, 1828, pp. 27, 30; Fitton, 1836; Gould, *in* Topley, 1875, fig. 20) it was not formally named until a century later (Kirkaldy, 1933). The lateral continuity of the Marehill Clay in the western Weald was recognised by earlier workers (e.g. Kirkaldy, 1933; Humphries, 1964), but it was not mapped as a separate member until the present survey was undertaken.

The most characteristic lithology is a dark grey, blocky weathering, silty clay which is locally sandy or glauconitic; dark grey and lilac clayey silts occur in places. Humphries (1964, p.31) noted yellow, white and brown sandy clay in the Marehill quarry. In the past the clays have been used for brickmaking.

Although the Marehill Clay has a fairly consistent outcrop width of between 50 and 100m, except on the steep northern limb of the Greenhurst Anticline, the borehole evidence suggests some variation in thickness along the outcrop. Near Fittleworth (0109 1881) an incomplete thickness of 10.67m was proved, and at Stopham (0270 1863), 1.6km to the east, the member is only 2.4m thick. At Pulborough boreholes adjacent to Pulborough Bridge (0466 1860 & 0464 1855) encountered 9.8m and 7.3m respectively; 700m to the east (0536 1858) the clay has thickened to 10.6m. A comparable thickness of 10.3m of sandy clay was proved beneath the Folkestone Beds at Coldwaltham (0205 1636).

A borehole in the Wiggonholt Syncline at Hardham (0332 1773) encountered two horizons (1.52m and 8.8m thick) of black and dark grey clay, each of which overlies a fine-grained sand very similar to the Pulborough Sandrock. Farther west, between Rogate and Petersfield, both the Marehill Clay and Pulborough Sandrock split into two (Bristow, 1981). This split is well documented in boreholes, and each of the clays and sands can be mapped separately at the surface. At Hardham there is possibly a similar splitting of these members which is not seen at the surface but which would explain the repetition of lithologies.

Between Rackham (046 149) and Sullington (100 145) the thickness of the Marehill Clay is estimated at 3 to 5m. Just east of Sullington, on the adjoining sheet (TQ 11 SW), 3.17m was proved in the IGS Washington Borehole (1264 1345).

Within the present area the Marehill Clay has yielded neither macrofauna nor microfauna; only lignite and seed-cases were amongst the residue from a washed sample from Pulborough (0464 1855). Nevertheless, the Marehill Clay is thought to fall within the Hypacanthoplites jacobi Zone of the Upper Aptian Substage.

3.1.5 Folkestone Beds

The Folkestone Beds consist dominantly of yellow, white, fawn and orange, medium- and coarse-grained, clean, well-sorted, moderately- to well-rounded, cross-bedded sands and weakly cemented friable sandstones. The coarser-grained sands are slightly pebbly in places and contain small well-rounded quartz pebbles up to about 5mm in diameter ; these are sometimes concentrated into distinct stringers. Only locally, as near Hesworth Farm (001 189), are the sands fine-grained. Sporadic thin seams (up to 12mm thick) of white, grey or lilac pipe-clay are present; they are largely confined to the bottomset beds but may also form drapes on the foresets. The foreset beds are mostly inclined at angles of 25° to 35°. Veins of secondary ironstone ('carstone') commonly form a rhomboidal trellis pattern in quarry faces.

Aspects of the cross stratification, which is invariably present, have been described by Allen and Narayan (1964). The cross-stratified units, up to 5m thick, have vector mean azimuths which indicate palaeocurrent direction dominantly from the north-west, not only in the Pulborough area, but for much of the rest of the Weald. Narayan (1963; 1971) concluded that depositiion of the Folkestone Beds took place by the lateral migration of sand waves in a shallow sea, possibly under tidal conditions.

The Folkestone Beds are the principal aquifer within the district and a number of water boreholes have been drilled through them. As a result the thickness of this formation is known from a number of scattered points and appears to show a marked variation across the district. Similar, but more extreme variation was noted in the Petersfield area to the west (Bristow, 1981). At Tripphill (0071 1760) on the west of the present district some 67m of Folkestone Beds were proved. Around Hardham (04 17) thicknesses between 44m and 56m were recorded, though an exceptional and incomplete thickness of 71.32m was encountered in a borehole 1.5km east of Hardham waterworks (0495 1755). Other boreholes proved 69.5m at Wiggonholt (0626 1673), 45m in the floodplain of the River Arun (0341 1635) 250m south of Hardham Priory, and 54.3m at Mill Farm (0092 1505), south-west of Watersfield.

The Folkestone Beds constitute a principal commercial source of sand which has been used primarily for building purposes including, until recently, the manufacture of tiles. Although there are no longer any working pits within the present sheet boundaries, there are large active workings immediately to the east at Sullington and Washington and to the west at Duncton Common.

No fossils, other than wood and burrow traces, have been found in the Folkestone Beds of this district. Evidence from outside the area suggests that the Folkestone Beds span the Upper Aptian/Lower Albian Substage boundary.

3.1.6 Gault

The Gault crops out in a long east-west strike vale beneath the scarp of the Upper Greensand, and in an east-west tongue in the centre of the Wiggonholt Syncline. Within this area there are no good permanent exposures in the formation, apart from some in the basal beds. The clay has been worked for brick making at several localities, but in most cases the pits are poorly documented. Consequently the stratigraphy and zonal sequence of the Gault in this area are little known.

The formation consists of grey and bluish grey silty mudstones, with sporadic bands of phosphatic nodules, which weather at the surface into tenacious brown and brown-grey mottled clays. The junction with the overlying Upper Greensand is transitional. At the base of the Gault in this district there is a persistent bed, 5mm to 12mm thick, of very hard, blood-red and blackish mottled, pebbly, limonitic, coarse-grained sandstone ('Iron grit' of some authors) the top and base of which are sharp and well-defined. The included pebbles, which are well-rounded and up to 5mm in diameter, consist dominantly of quartz. Fragments of 'Iron grit' are locally prominent in the soil at outcrop, allowing the base of the Gault to be mapped with precision.

Owen (1971) has demonstrated that the Gault of the present district lies on the crest of a 'high' which affected sedimentation during the Lower Albian and earliest Middle Albian. Sediments of Lower Albian age are absent over the high . Similarly the lowest subzones, i.e. the Hoplites (Isohoplites) eodentatus and Lyelliceras lyelli subzones of the Middle Albian substage, seem to be absent, and deposits of spathi Subzone age rest directly on the 'Iron grit'. Owen (1971, p. 146) regards the 'Iron grit', which is unfossiliferous, as the indurated top of the Folkestone Beds; Kirkaldy (1935a, p.532), on the other hand, considered it to be the basal bed of the Gault. As this bed, unlike the underlying Folkestone Beds, has a high pebble content and since it seems to pass laterally into pebbly sandy clays of Lower Albian age, the present authors believe that it constitutes the basal bed of the Gault. The incorporated pebbles may have been derived by the destruction and winnowing of pebbly Lower Albian deposits, which were eroded during the gradual uplift of the district to form a 'high' during the Lower Middle Albian Substage.

The only dated section in the Gault is at the Marley Tile Co.'s pit (0953 1389), Sullington, where basal fossiliferous mudstones have yielded ammonites of the *spathi* Subzone of the *dentatus* Zone. No evidence is available for the higher subzones and zones of the Middle Albian, nor of the basal subzones of the Upper Albian *Mortoniceras* (*M*). *inflatum* Zone, to which the highest clay of the Gault of this area can probably be assigned.

Only one borehole, at Amberley (0282 1323), has penetrated the complete Gault succession; a total thickness of 91.6m was proved and is assumed to be representative of the sheet area.

3.1.7 Upper Greensand

The Upper Greensand, which forms a prominent north-facing escarpment, is traversed by sunken lanes in which the bulk of the exposures occur. The greater part of the formation consists of bedded, fawn, grey and greenish-grey, calcareous, variably argillaceous, bioturbated siltstones with a characteristic 'streaky', wispy-bedded structure produced by lenticles of varying clay content and grain size. Minor cross-lamination occurs locally and the siltstones are slightly glauconitic in places. They weather pale buff and whitish in colour. In addition, there are intermittent, lenticular beds of very hard, grey or bluish-grey, calcareous, uniform siltstones with a sub-porcellanous texture, which weather fawn, buff and whitish in colour. These are colloquially known as 'malmstone' and have been worked in the past as a local building stone as, for example, at Amberley. Locally the sediments coarsen to very fine-grained sandstones, but these are subordinate.

At the base of the formation the siltstones become very argillaceous and there is a passage down into the Gault clay. At the top of the Upper Greensand there are said to be green glauconitic sands immediately below the base of the Chalk (Reid, 1903) but the sands were not detected at this level during the present survey.

Boreholes penetrating the whole of the Upper Greensand in the village of Bury indicate the total thickness of the formation to be about 30m. No diagnostic fauna is known from the Upper Greensand of this district but limited evidence from elsewhere in the Western Weald (Owen, 1975, p.490) suggests that the formation represents the highest part of the *Mortoniceras* (*Mortoniceras*) *inflatum* Zone and the whole of the overlying *Stoliczkaia dispar* Zone.

3.1.8 Chalk

The Chalk outcrop gives rise to the bold escarpment of the South Downs. Gently undulating chalk downland characterises the dip slope which is dissected by numerous dry valleys.

The present survey follows recent I.G.S. practice on the adjoining Brighton and Worthing (318) Sheet (Young and Lake, in preparation) in mapping Upper and Middle Chalk undivided. The local absence of the Chalk Rock, which elsewhere forms the basal unit of the Upper Chalk, or of any other mappable bed at this level makes separation of the two divisions impracticable. The base of the Melbourn Rock defines the Lower/Middle Chalk boundary.

3.1.8.1 Lower Chalk

The Lower Chalk contains a considerable proportion of argillaceous sediment and is characterised by grey and greyish-white marly chalks contrasting with the pure white limestones of the overlying beds. At the base, however, there are bright green, clayey, fine-grained, glauconitic sands, which constitute the so-called Glauconitic Marl. This is usually regarded as the basal unit of the Chalk Marl Member. It is generally no greater than 2m in thickness, but may be as much as 4m thick in the vicinity of Bury. These beds are known to contain phosphatic pebbles and derived fossils, and usually rest with a sharp base on the burrowed top of the underlying Upper Greensand.

The Glauconitic Marl passes up by a gradual diminution of its glauconite content into the main body of the Chalk Marl which comprises rhythmically interbedded grey marl and whitish-grey, relatively soft, marly chalk. It is the Chalk Marl which forms the gentle lower slope of the South Downs scarp face.

The Chalk Marl is succeeded by the Grey Chalk member in which rather less marly, massive, blocky weathering, poorly fossiliferous, whitish-grey chalk is dominant. Many of the now-abandoned chalk pits exploited these beds.

The uppermost member of the Lower Chalk, the Plenus Marls, consists of thinly interbedded marl and marly chalk which commonly have a pale greenish tint. It has been demonstrated (Jefferies, 1963) that the constituent beds of the Plenus Marls persist over great distances and that there is an important erosion surface at their base.

The top of the Lower Chalk is taken at the base of the Melbourn Rock (see 3.1.8.2). The total thickness of the formation is estimated to be 55m in the present area.

3.1.8.2 Middle and Upper Chalk, undivided

This formation is dominated by white, pure chalks which, in the upper part, are characterised by numerous courses of nodular flints and sporadic tabular bands, plus several thin marl bands. Beds of nodular chalk are common at certain levels throughout the sequence. Mortimore (1979; in press) has indicated that the sequence can be broken down into five distinctive and persistent members, each with widely correlatable marker beds. Although these are probably readily recognisable in cliff and quarry sections, it is doubtful whether they could be mapped on a regional basis. The present survey has not attempted to examine the Chalk in sufficient detail to elucidate the local sequence in terms of Mortimore's five members.

The Melbourn Rock constitutes the basal unit of the formation; it consists of 3-4m of hard, creamy-white, locally pinkish, nodular chalk with some marly wisps. Locally it gives rise to a marked feature on the scarp face of the Downs and the outcrop is usually easy to trace. Immediately above the Melbourn Rock there are creamy-white soft chalks, some of which are nodular, with marly intercalations; they contain numerous *Inoceramus* shells and shell detritus. The bulk of the sequence above the Melbourn Rock, corresponding to the Middle Chalk (up to the top of the *Terebratulina lata* Zone), consists of thick-bedded chalk with sporadic marl bands and a few courses of flints towards the top. The total thickness of these beds and the Melbourn Rock is about 60m.

Beds corresponding to the Upper Chalk consist typically of pure, white, homogeneous, well-jointed limestones. An estimated 80m are represented in the present area. Nodular chalks and hardgrounds occur in the *Holaster planus* and *Micraster cortestudinarium* Zones. Numerous widely persistent courses of flint nodules and bands of tabular flints characterise the zones of *H. planus*, *M. cortestudinarium* and *M. coranguinum*, as well as the highest beds present in the area which probably belong in the Zone of *Offaster pilula* (see Gaster, 1932). The Zones of *Uintacrinus socialis* and *Marsupites testudinarius* consist of pure white chalk with few flints and some marly bands; the differential erosion of these beds has led to the development of the secondary escarpment on the South Downs dip slope which is formed of more resistant chalk containing many flint bands.

3.2. Local Details

3.2.1 Weald Clay

At outcrop within the district the Weald Clay consists of mottled yellow or orange and grey clays or silty clays. There is much gravelly and sandy Head on the surface of the Weald Clay in the western part of the Greenhurst Anticline (around 084 157).

3.2.2 Atherfield Clay

In the valley (058 199) to the north-west of Broomershill the Atherfield Clay comprises grey clayey silt, glauconitic clayey sand and sandy clay.

There is a narrow outcrop of Atherfield Clay on the northern edge of the district where the thickness varies from 5 to 10m. Locally, however, the Hythe Beds rest directly on the Weald Clay (e.g. around 099 196), but this is probably a result of cambering and not an erosional, or non-depositional feature. Over this tract the Atherfield Clay consists of various lithologies, including mottled red and grey silty clay, glauconitic sandy clay, brown and grey silty clay and red and brown clayey silt.

The formation has only a narrow outcrop on the northern limb of the Greenhurst Anicline and comprises mottled reddish brown and grey silty clay, dark greyish brown silty clay and mottled orange and grey very silty clay. On the south side of the anticline the Atherfield Clay appears to be absent from the tract between the River Stor (081 154) and Northlands Lane (0927 1556). To the east side of the lane, yellowish brown glauconitic sandy clay can be augered immediately beneath the Hythe Beds, except where Head obscures the outcrop.

3.2.3 Hythe Beds

Exposures in the Hythe Beds in the north-western part of the area are rare, but augering generally reveals buff, medium-grained sand and glauconitic clayey sand. The junction with the Fittleworth Beds can be seen in the river cliff of the Arun (0325 1959). Here, beneath the Fittleworth Beds, the following strata are exposed:

	Thickness m
Sandstone, medium-grained, well-bedded, finely laminated, friable, calcareous; the laminae are mostly 1 to 3cm thick, but some are up to 7cm	1.1
Doggers, 0.2m thick and 1.6m long, of ferruginous sandstone; impersistent	
Sandstone, medium-grained, thinly bedded but in thicker units (up to 0.3m) than the upper sandstone. At least one dogger 0.6 x 0.15m	1.2+

The dip is 12° towards the south-west.

On the opposite side of the river (0336 1986) some 3m of thinly bedded, buff, medium-grained sandstone with thin (10mm thick by 1m long) chert lenses are visible in an old quarry. There are irregular joints at right angles to the bedding and parallel to the scarp.

Between the river and the railway line to the east, the Hythe Beds form long dip slopes with a general dip to the south-west or south-south-west. Laneside exposures (around 040 197) to the east of Combelands are generally in thinly bedded, glauconitic, buff, medium-grained sandstone with calcareous doggers.

At Pulborough south-westerly dipping buff, glauconitic, medium-grained sandstones are exposed in the road bank; at one point (052 195) a 150mm seam of mottled orange-brown and grey fuller's earth is present. About 1m below it there is a line of more or less continuous doggers which have a maximum thickness of 0.2m.

In the Broomershill area the Hythe Beds form long dip slopes which fall to the south. To the north-east of Brook House 10m of massive, buff, glauconitic, medium-grained, friable sandstone in units 1.5m thick are exposed in an old quarry (0680 1993); thinner beds within the more massive beds are etched out by weathering; scattered doggers 0.3m x 0.9m also occur. The whole face is broken by vertical east-west and north-south joints.

A 0.46m 'grey clay' which lies 11m above the base of the Hythe Beds in a borehole at Nutbourne Common (0744 1807) may well be a seam of fuller's earth. In the lane leading north from Nutbourne there is a good exposure of 3.5m of buff, glauconitic, fairly massively bedded, flaggy-weathering sandstone with more-or-less continuous lines of doggers 0.3m thick. The dip is 16° at N140°.

To the north of West Chiltington a greyish buff waxy clay, possibly fuller's earth, was augered at two points (0890 1891 and 0923 1917) at about the same stratigraphical level, but the clay could not be traced on either side of each auger hole. Up to 6m of buff glauconitic medium-grained sandstone with scattered doggers is visible in the sunken lanes around West Chiltington. In an old pit (099 183) on the eastern margin of the district 6m of yellowish brown, medium-grained, friable sandstone with doggers is exposed, dipping 17° at N220°.

On the steeply dipping northern limb of the Greenhurst Anticline the Hythe Beds have only a narrow outcrop. Up to 2m of buff, glauconitic, medium-grained sandstone dipping 25° just west of north can be seen 180m south of Roundabout Farm (0886 1610). To the north of Hurston Street Farm friable, orange, medium-grained sandstone with doggers dips 14° at N025° (0780 1603). In the sunken lane by the farm (0775 1575) some 6m of buff glauconitic sandstone with doggers can be seen; the dip here is 14° at N295°.

On the south side of the anticline a thin seam of glauconitic sandy clay in the lower part of the Hythe Beds, which is similar in lithology to the Fittleworth Beds, can be mapped over a 1km tract (0750 1535 - 0850 1537). To the east, about 3m of buff, glauconitic, medium-grained sandstone with doggers dips 15° south in the sunken lane (0930 1554) north of East Wantley. Temporary excavations on a building site at Storrington (081 149) revealed up to 5.4m of thinly-bedded, glauconitic sandstone with bands of grey doggers.

3.2.4 Sandgate Beds

3.2.4.1 Fittleworth Beds

Exposures in this member are poor, but augering generally reveals mottled orange and grey glauconitic sandy clay. Bricks were formerly made from this deposit at Fittleworth (0143 1954); a sample from the vicinity had a high montmorillonite content (D. Highley, personal communication).

An exposure (0325 1959) in the river cliff of the River Arun reveals the junction with the underlying Hythe Beds. At the base of the Fittleworth Beds there is a rubbly, cross-bedded, fossiliferous dogger, 0.6m thick, which passes up into buff-brown, silty and clayey fine-grained sand with a trace of bedding. The dogger rests on a well bedded, finely laminated, soft, calcareous, friable sandstone belonging to the Hythe Beds. The fossils from the basal Fittleworth Beds have been listed by A.A. Morter (in Bristow, in press). The faunal assemblage yielded by the dogger appears to belong to the lower part of the Parahoplites nutfieldiensis Zone, i.e. the Tropaeum subarcticum subzone.

In a borehole (0744 1807) at Nutbourne Common the Fittleworth Beds are described as 45.87m of dominantly sandy clay with some 'rock'. Although the member consists mainly of glauconitic sandy clay, a smooth grey clay was augered at two points (0709 1867 and 0800 1862) near Nutbourne. On the northern limb of the Greenhurst Anticline the general lithology is the characteristic glauconitic, yellowish brown sandy clay.

Between Rackham and Sullington the only exposure (0876 1462) is in the bed of the River Stor, 80m north-north-west of the Mill Pond at Storrington, where dark greyish-green, glauconitic, clayey, fine-grained sand can be seen at a level just below the base of the Marehill Clay.

3.2.4.2 Pulborough Sandrock

Pulborough Sandrock borders the northern part of Hesworth Common (002 193) where, for the most part, it consists of fine-grained, locally cross-bedded, buff and orange sands. These are well exposed in the old sunken lane (0060 1933) and in the main road cutting (0062 1934), where up to 8m of sand with a southerly dip of about 17° can be seen. To the south-east some 6m of massive, buff-yellow, fine-grained sands are exposed in an old quarry (0082 1927) 100m west of Fittleworth church. An old pit (0040 1942), 180m west-north-west of the road cutting, exposes the basal beds, beneath 1 to 2.5m of Head; they consist of very glauconitic, slightly clayey, bioturbated fine-grained sand with little obvious stratification. This sand includes groups, up to 0.3m thick, of lilac and grey clay beds and streaks, rarely exceeding 1cm in thickness, with thin interbedded sands. Some of the sand beds have scattered pellets of grey and lilac clay. It was presumably from this pit that Bull and Kirkaldy (1947, p.82) recorded Thetironia minor and Corbula striatula. Two old pits in the Pulborough Sandrock on Limbourne Hill (017 192 and 019 192) both reveal about 2m of buff, grey and yellow fine-grained sands, locally with thin (max. 10mm) grey clay seams. The Marehill Clay occurs in the upper part of the eastern pit. East of the River Arun springs issue from the base of the Pulborough Sandrock along the steep slope of Pulborough Park Plantation. At the top of the lane heading north from Park Farm (0395 1893) the Pulborough Sandrock crops out as 6m of massive, fine-grained, friable, buff and grey sandstone dipping at 12° to the south-east (see section in Humphries, 1964, p. 51). A short distance down the lane (0396 1897) the sand is for the most part uncemented, or only weakly cemented, with large scattered ferruginous, fossiliferous sandstone nodules. A revised list of the fauna obtained from these nodules by Mr. A.A. Morter is given in Appendix I.

On the east side of the railway at Pulborough up to 4m of yellowish buff friable sandstone can be seen in largely overgrown pits (0449 1875). The section in the main road 240m to the east (0473 1872) is generally regarded as the type locality of the Pulborough Sandrock. Up to 5m of massive, friable, fine-grained sandstone, dipping south at 7°, are exposed. The uppermost part of the sandstone is iron-cemented and the junction with the Marehill Clay is well exposed.

In a borehole at Hardham (0332 1773) there are two groups of sandstones which could be referred to the Pulborough Sandrock, both overlain by clays which could be assigned to the Marehill Clay. It is difficult to know which, if either, of the two corresponds to the Pulborough Sandrock at outcrop as both the upper (1.52m thick) and the lower (3.3m thick) are much thinner than anticipated. However, much farther west, between Elsted and Petersfield, both the Pulborough Sandrock and the Marehill Clay split into two mappable units, and so it is possible that they do the same at Hardham, thus accounting for the duplication. Alternatively, the duplication may result from faulting, but this is doubtful.

The Pulborough Sandrock forms a prominent scarp at Marehill where excellent exposures are still visible in the old pit and galleries which were worked for moulding sand. On the north side of the pit some 3m of friable, buff to orange, fine-grained sandstone, flaggy-weathering in the uppermost 0.8m, can be seen. On the south side are the galleries which extend southwards for about 20m; these are dug into about 2m of orange-brown, cross-bedded, iron-stained, friable sandstone. The top 0.3m or so of the sandstone, which form the roofs of the adits beneath the Marehill Clay, is iron-cemented. The overall dip of the beds is 14^{o} at $N200^{o}$. Most of the gallery entrances are still open and well exposed, much as they were in 1935 (Kirkaldy, 1935b, pl. 15).

Some 900m to the south-east of Smock Alley the Pulborough Sandrock forms two prominent low hills (095 168 and 095 165) the former of which is capped by Marehill Clay. Small outliers of Pulborough Sandrock are found to the north of Parham Park, between Sparrite Common (052 153) and just east of Bog Common (070 156). It is probably from the road-side exposure (0534 1525), 150m south of Sparrite Farm, that the fossiliferous material first recorded by Mantell (1822) was obtained.

To the north-east of Washingham (052 160) the base of the Pulborough Sandrock is marked by a line of springs. The most westerly exposure of the member within the Greenhurst Anticline is in the river cliff of the River Arun (0311 1186) where ribs of ferruginous, well-cemented sandstone at the top of the member crop out beneath the Marehill Clay.

Between Rackham and Cootham the Pulborough Sandrock forms a low but distinct scarp feature. A temporary excavation (0728 1467) at Cootham revealed up to 1.2m of pale fawn and yellow, clean, well-sorted, medium-grained sands. The Pulborough Sandrock dies out 280m to the east and is no longer recognizable as a distinct member of the Sandgate Beds.

3.2.4.3 Marehill Clay

Large tracts of Hesworth Common, Fittleworth (005 192), are underlain by grey silty clay of the Marehill Clay. The upper contact with the Folkestone Beds is commonly marked by springs, e.g. at (0052 1883), which are associated with extensive tracts of Head. The thickness of the Marehill Clay is about 8m in this vicinity. Old quarries (0190 1915) on the east side of Limbourne Hill have poor exposures of grey, and mottled grey and orange silty clay above the Pulborough Sandrock.

A temporary exposure (0261 1911) on a small outlier of Marehill Clay at Stopham revealed 1m of glauconitic, silty grey clay, above orange, fine-grained Pulborough Sandrock. A borehole 230m south-west of Stopham Church (0249 1875) proved 5.0m of 'firm brown and grey mottled clay and green sand' above the Pulborough Sandrock, and a borehole nearby (0269 1863) passed through a total thickness of 2.4m of stiff, bluish grey-green mottled silty clay between the Folkestone Beds and Pulborough Sandrock.

Between the River Arun and Pulborough, grey silty clays and, to the east of Park Mound (038 190), clayey, fine-grained sand and glauconitic silty clay can be augered.

A former brickpit (0445 1870) near Pulborough Station is largely overgrown and partially built over, but temporary exposures during recent building revealed up to 3m of very dark grey, shaly silty clay above the Pulborough Sandrock. In the road cutting (047 187) to the south of Pulborough Church the junction of the Marehill Clay and Pulborough Sandrock is well displayed; up to 10m of dark grey silty clay occurs in the overgrown road bank.

The junction of the Marehill Clay with the Pulborough Sandrock at Marehill can be readily located in the lane (063 186) adjacent to Manor Farm. It is also well exposed in the old quarry (0640 1864) to the east. This is the type locality of the Marehill Clay, where the clay was apparently stripped off as overburden and possibly used for brickmaking, as at Pulborough. Exposures in the dark grey, blocky weathering, silty clay are poor, but can be seen above the openings of some of the galleries. Humphries (1964, p. 51) measured a section in this pit when both the Marehill Clay (2.97+m thick) and Pulborough Sandrock (5.56+m thick) were better exposed.

On the west side of the River Stor the outcrop is largely hidden beneath drift and can be recognised at the surface only intermittently. In a borehole (0580 1614) 300m south-south-west of Upperton's Barn, the Marehill Clay was described as 3.6m of greyish green clay, beneath 2.9m of black sandy Head. The Marehill Clay is next seen near Greatham where it crops out as a grey silty clay in the fields between Quell Farm (033 159) and Glebe Farm (040 153). Up to 4m of greyish brown silty clay can be augered in the river cliff (0312 1586) above the cemented top of the Pulborough Sandrock.

Marehill Clay, usually described as hard black clay, was proved at the base of many of the boreholes drilled by the Southern Water Authority in the Hardham area. Only one borehole (0332 1773) penetrated the complete thickness of the Sandgate Beds. In this there appear to be two sequences referable to the Marehill Clay; an upper one, 1.52m thick, of very dark grey and black fine-grained sandy clay, and a lower one, some 14m below, comprising 8.8m 'of black or dark grey silty clay' resting on what appears to be Pulborough Sandrock. Both members may be repeated by faulting; alternatively both may have split into two as happens farther west (see 3.2.5). A nearby borehole (0354 1764), however, proved 20+m of Marehill Clay below Folkestone Beds, with no sandstone intercalation.

Between Rackham and Storrington the Marehill Clay is exposed at only one locality, namely in the stream bank (0752 1449) 50m south of the main road at Cootham, where dark grey, shaly silty clay near the top of the member can be seen below 1.7m of Head. At Rackham and throughout Parham Park augering revealed dark grey and lilac silty clay and clayey silt. Dark grey silty clay was proved near the old mill pond in Storrington (0877 1451) and also on the north-east side of Sullington Warren (0972 1469).

3.2.5 Folkestone Beds

The higher parts of Hesworth Common are capped by outliers of Folkestone Beds (002 190 and 005 192) at the base of which springs, associated with spreads of Head, are locally common. Good exposures of up to 4m of ferruginous fine-grained friable sandstone, very similar to the Pulborough Sandrock, and dipping at between 4° and 12° to the south-east can be seen in the sunken lane to the north of Hesworth Farm (0007 1891 - 0023 1891).

On the south side of the River Rother, by Fittleworth station, up to 4m of massive, ferruginous, medium- to coarse-grained, friable sandstone is exposed in an old quarry (007 181) To the south-west, on Coates Common (003 175) and immediately beyond the sheet boundary, there is a large disused pit (SU 998 176) where some 15m of fine-, medium- and coarse-grained, friable, buff and yellow, cross-bedded sands are exposed; thin seams, generally less than 1cm, but with some up to 5cm, of greyish-pink clay are present.

Fittleworth Common (015 188) is also underlain by Folkestone Beds which form a prominent north-facing scarp, but there are few exposures. A roadside section (0191 1895) reveals up to 2m of reddish brown massive sandstone. To the north-east of Lee Farm there is a patch (023 188) of glauconitic, greyish or yellowish brown sandy clay within the lower part of the Folkestone Beds.

In an old quarry (026 188) to the south of Stopham Church some 4 to 5m of ferruginous, medium- to coarse-grained sand with irregular 1cm ironstone layers are seen; the dip is 30^{o} at $N110^{o}$. Cross-bedded, ferruginous, coarse-grained sandstone is visible in another old quarry (0301 1838) behind the White Hart and in the old river cliffs (0306 1850) to the north. Further east, bright red medium- and coarse-grained sands are commonly ploughed up in the fields (0390 1865) to the south of Park Farm.

Hurston Warren (07 17) is a terrace-covered flat where the Folkestone Beds crop out all the way round on the old river cliffs. Here, in an old pit (0673 1710), 4m of buff and white, medium- to coarse-grained, friable sandstone beneath 1m of flinty sand are exposed.

There are several large disused quarries at Coldwaltham. On the north side of the most westerly pit (0136 1663) the junction with the Gault can be seen; here, beneath the basal 'Iron grit' of the Gault 2 or 3m of buff, medium, cross-bedded friable sandstone are exposed. Elsewhere in this pit up to 7m of Folkestone Beds are exposed. The average dip is about 14°E. A number of open joints trend at N85° and are inclined 85° to the south. Another pit (019 164) has a face about 12m high in fine-, medium- and coarse-grained, buff, cross-bedded, friable sandstone. A third pit (021 164) reveals about 18m of similar beds.

Fine- to medium-grained sands appear to be the dominant lithology in an outlier of Folkestone Beds west of Glebe Farm (037 154).

The Folkestone Beds give rise to a prominent east-west ridge between Parham and Sullington, on which the greater part of Storrington is built. There are sporadic small exposures of vari-coloured, mainly coarse-grained, friable sandstones. In the sandpit (0501 1442) 150m south-west of the former Fighting Cocks Inn, 8m of varicoloured sands and weakly cemented sandstones are seen. These are medium- and coarse-grained, clean and well sorted, with scattered very small quartz pebbles. The cross-bedded units range from 1m to 2m in thickness. The foresets dip at 25°-30° between south and south-east, and pass down into thin bottomset beds ranging from 5mm to 12mm in thickness. The latter comprise layers of fine-, medium- and coarse-grained sand interbedded with thin seams of greyish-white, smooth pipeclay, some of which are disrupted into stringers of clay flakes.

The best section within the grounds of Parham Park is to be seen in the former sandpit 250m east-north-east of Parham House (0628 1428). This comprises 6m of pale yellow and buff, medium- and coarse-grained, cross-bedded, friable sandstones with a few orange ferruginous bands. The foresets are straight and planar and dip at up to 35°; they meet the bases of the cross-bedded units at sharp angles (Type I units of Allen & Narayan, 1964). Some cross-beds grade up into very coarse sand at the top with sharp upper surfaces. The cross-sets dip to the south and south-east.

At the Marley Tile Co's pit at Sullington (095 139) up to c 25m of mainly pale yellow and buff sand and soft, friable sandstone are exposed beneath the basal 'Iron grit' of the Gault. The uppermost few metres are bright red-stained. The whole succession is strongly cross-bedded, most of the cross-sets being of the order of 1.2m in thickness. The sands are clean, mostly coarse- to very coarse-grained, well-sorted and well-rounded with, at some levels, a proportion of quartz granules or very small well-rounded quartz pebbles (up to 5mm in diameter) which are commonly aggregated into stringers of pebbly sand. The foresets dip for the most part between 20° and 30° towards the south-south-east. There are frequent strings of small blackish ferruginous concretions consisting of iron-cemented sand. Rare partings of whitish pipeclay flakes are present, as are sporadic fragments of carbonaceous fossil wood. At some horizons both large and small burrow traces weather out boldly in the sand face. A reticulate trellis-like pattern of hard, ferruginous veins is particularly evident in the upper part of the section.

3.2.6 Gault

The 'Iron grit' was probably formerly exposed at the top of the old pit (007 181) by Fittleworth station, but the upper part of the section is no longer visible. However, a ditch section (0081 1806) close by showed 0.8m of bluish grey clay, overlying 0.05m of hard red pebbly limonitic grit which in turn overlay the Folkestone Beds. This must be close to the similar section described by Maw (1869). 'Iron grit' was noted in field brash at a number of points to the west of Tripphill and to the south-west and south-east of Horncroft Farm.

The junction between the Gault and Folkestone Beds can be seen in the top of an old pit (0186 1663) at Coldwaltham where 0.8m of greyish brown clay overlies 0.05m of red, hard, pebbly, ferruginous grit. The latter was found at several localities in soil brash along the outcrop.

Around Hardham much of the Gault outcrop is covered by River Terrace Deposits which give rise to springs at their base. A temporary section (0345 1767) at the waterworks showed a maximum of 5m of homogeneous shaly clay, devoid of phosphatic nodules, above the 'Iron grit' which is 0.07m thick; the basal 3cm of the Gault consisted of khaki coloured sandy clay with scattered quartz pebbles up to 1cm diameter.

The maximum thickness of Gault preserved in the Wiggonholt Syncline is at least 25m, as proved in a borehole (0628 1671) at Wiggonholt Farm. Slipping of the Gault has taken place along the steep old river cliff (058 171) to the north-west of the farm.

The outcrop between Hale Hill Farm (0042 1466) and Timberley Farm (0208 1414) is devoid of exposure but stiff grey clay can be augered in ditches. East of the River Arun the Gault occupies a low-lying clay vale in which exposure is minimal, but the basal 'Iron grit' is prominent in field brash at a number of localities. It was exposed in the floor of a minor stream 250m east-south-east of Cootham Farm (0741 1391), beneath 1.7m of Head. The upper part, 0.05 - 0.07m in thickness, shows the normal lithology; it rests on 0.15m of much less hard, orange and blood-red mottled, coarse-grained, slightly pebbly, patchily limonitic sandstone with soft, weakly cemented pockets.

The best section in this tract is that at Marley Tile Co's pit at Sullington (0953 1389). It occupies the uppermost portion of the southern face above the Folkestone Beds, but is at present inaccessible. However, a record of the sequence has been published (Owen, 1963), which may be summarised as follows:

		Thickness m
Bed 5	Fawn-grey clay with ferruginous and marly lenticles. Poorly preserved *Hoplites* (*H.*) cf. *dentatus* in the lower part	1.83
Bed 4 (iii)	Grey, slightly gritty clay with marly seams, yielding *Inoceramus concentricus* and *H.* (*H.*) cf *dentatus*	1.83
(i) & (ii)	Grey glauconitic clay, ferruginous in upper part	0.46
Bed 3	Grey gritty glauconitic pebbly clay	0.25
Bed 2	Mottled grey and ochreous pebbly clay with pockets of quartz sand or glauconite	0.10-0.13
Bed 1	'Iron grit'	0.08

Folkestone Sand below

Blocks of the 'Iron grit', which have fallen from the outcrop, can be examined in the pit floor.

3.2.7 Upper Greensand

Minor exposures in the Upper Greensand are common throughout the outcrop which is commonly characterized by a surface brash of calcareous siltstone on cultivated fields. The lithology is much the same in all exposures.

A section in West Burton (0002 1401) reveals greenish grey and buff, streaky, wispy-bedded, slightly glauconitic, flaggy-weathering, fine-grained sandstone with many dark grey muddy wisps, 0.4m; on greyish fawn, buff-weathering, hard calcareous siltstone, 0.3m; overlying grey and buff, soft, bioturbated, wispy-bedded, argillaceous siltstone, 1.2m.

At Bury, up to 6m of thickly-bedded Upper Greensand can be seen in cliff-like exposures (0119 1353) in the banks of a sunken road, named 'The Hollow'. The beds mainly comprise whitish and pale buff, "streaky", calcareous siltstone and very fine-grained sandstone with some bands of much harder, buff, more uniform siltstone.

To the east of the River Arun, at Amberley, there are several good exposures at intervals along the ancient river cliff bordering Amberley Wild Brooks. The best of them is on the west side of the Village between the Castle (0274 1322) and the railway line (0247 1317). Here up to 4m of grey and fawn, whitish-weathering, thick-bedded, calcareous, variably argillaceous, bioturbated siltstones are visible, all exhibiting the characteristic streaky, wispy-bedded structure. The section includes one persistent but lenticular bed of hard, grey, uniform, porcellanous siltstone. Other sections showing similar sequences can be seen to the east of the castle; in these dips of the order of 5° to the south were recorded. Similar beds can be seen in the banks of the sunken roads just north of Rackham Farm (0507 1357) and adjacent to Waterfall

Cottage (0915 1301), near Storrington.

3.2.8. Lower Chalk

The Chalk Marl Member, including the Glauconitic Marl at the base, is poorly exposed. East of the River Arun the Glauconitic Marl was not detected, but it was formerly seen in the railway cutting at Amberley by Reid (1903). West of the River Arun, at Bury and through to the western margin of the sheet, bright green clayey glauconitic sand can be augered, particularly in the banks of the A 29 road cutting (0097 1340).

The overlying Chalk Marl is, for the most part, seen only as meagre exposures in tracks and roads traversing the South Downs scarp face. However, bedded marly chalk is visible in the much overgrown pit 100m south of the Chantry (0917 1270). Reid (1903) recorded that grey, gritty marl full of small brachiopods was present in the road cutting adjacent to this pit, at a level about 9m above the base of the Lower Chalk. Field brash of pale creamy grey, marly, fossiliferous chalk close to the railway cutting at Amberley (c 023 129) yielded many well-preserved ammonites at an horizon probably just above the Glauconitic Marl; these indicate the <u>Mantelliceras</u> <u>mantelli</u> Zone (see Appendix II).

The Grey Chalk Member was formerly worked in many pits along the South Downs scarp face, most of which are now degraded and overgrown. Creamy-white, soft, blocky, massive marly chalk can be seen in pits at the foot of Bury Hill (0068 1281), Grey Friars Farm (0795 1285) and south-south-east of the Chantry (0925 1255). The best section in the Grey Chalk is at Chalk Pits Museum, Amberley, in the vertical quarry face bordering High Titten (0308 1233) where up to about 40m of massive and thick-bedded, marly, blocky chalk with intermittent marl bands is present.

The Plenus Marls were seen only as minor exposures in tracks climbing the Chalk scarp face, immediately beneath the Melbourn Rock.

3.2.9 Middle and Upper Chalk, undivided

The Melbourn Rock at the base of the succession commonly forms a recognizable feature on the Chalk scarp face. Locally, a brash of nodular chalk is visible along the outcrop. The only substantial exposure is adjacent to Amberley station, behind the hut at the entrance to Chalk Pits Museum (0268 1182) where the lowest 1.5m of the section consists of hard, creamy-white chalk with an ill-defined nodular structure and a rough texture. In this vicinity the Rock has yielded Inoceramus labiatus, Rhynchonella cuvieri and Conulus subrotundus (Gaster, 1932). It is overlain by c 4m of soft, white, blocky, shelly chalk yielding numerous valves and fragments of I. labiatus.

The most complete sections of the Middle Chalk are in the large abandoned pits close to Amberley Station where the total thickness is estimated at between 55m and 60m. These sections fall within the zones of I. labiatus and Terebratulina lata. The sections are referred to by Reid (1903, pp. 25-26) and Gaster (1932, pp. 214-215). They comprise mainly thick-bedded, white, pure chalks with intermittent marl bands and beds of nodular chalk. Bands of flints can be seen in the uppermost beds.

The large quarry 700m south-west of Houghton church

(0135 1110) has high vertical faces exposing about 45m of chalk, the lowest 10m of which are Middle Chalk of the *T. lata* Zone according to Gaster (1932, p. 217). This consists of massive white chalk with courses of flints and a few marl seams.

Another pit section in the Middle Chalk at Bury Hill (0068 1243) reveals about 10m of creamy-white, blocky, well-jointed chalk with rare small flints, and containing thin (c. 0.2m) grey marl bands near top and base.

The greater part of the South Downs escarpment is underlain by the Upper Chalk. In the quarry near Houghton (0135 1110) a total of 36m of bedded and massive white chalk with courses of both tabular and nodular flint, and some nodular chalk bands are exposed. According to Gaster (1932, p.217) this section lies within the zones of *H. planus* and *M. cortestudinarium*.

Fossiliferous chalk in the *H. planus* zone was formerly exposed in the railway cutting 1km south of Amberley station (0262 1070) (Reid, 1903, p.28; Gaster, 1932, p.215). A recent large excavation nearby (0267 1085) revealed 5m of thick-bedded chalk with scattered nodular flints and a thin tabular flint band 2m below the top.

4. STRUCTURE

The area lies on the southern flank of the major Wealden Anticlinorium, and the regional structure is one of strata gently inclined to the south. Dips, for the most part, are no greater than about 5°. Superimposed on this regional structure are the easterly trending Greenhurst Anticline and the complementary Wiggonholt Syncline to the north (Figs. 1 and 2). The broad structural picture has been clearly established by mapping, but details of the individual structures are few as much of the ground is poorly exposed.

The gentle dips on northern limb of the Wiggonholt Syncline are mainly of the order of 5°, and the northern margin of the area is characterised by the long, gentle dip slope of the Hythe Beds. However, this northern limb appears to be modified by a slight monoclinal flexure, the alignment of which coincides, more or less, with the outcrop of the Pulborough Sandrock as far east as Marehill. Dips up to 17° have been recorded along this outcrop, with the steepest dip occurring at Fittleworth Plantation (0058 1936). Another dip of 17°, in basal Hythe Beds, was measured at the eastern margin of the district, 700m east-south-east of Hatch's Farm, West Chiltington (0989 1330); this lies on the alignment of the monoclinal flexure as extrapolated eastwards from Marehill. Structural cross-sections indicate that on the northern limb of the Wiggonholt Syncline dips are greater to the north of the monoclinal flexure than to the south.

The southern limb of the Wiggonholt Syncline (the northern limb of the Greenhurst Anticline) is considerably steeper (Fig. 2 and 3) as the outcrops of the Hythe Beds and the three members of the Sandgate Beds are all very narrow. Within this tract the only recorded dip was one of 25° to the north-north-west at a locality (0886 1610) 180m south of Roundabout Farm. Within the core of the syncline up to 30m of Gault are preserved. Weald Clay is brought to the surface in the Greenhurst Anticline east of Hurston Street Farm (around 092 158). Dips on the southern limb of this structure appear to be quite gentle and probably reach little more than 5°.

Faulting does not appear to be an important structural element, and only a few minor displacements have been recognised. An east-west trending strike fault to the north of Stopham (around 030 195), which has a displacement of about 15m, has been traced for approximately 1km. A fault to the north-east of West Chiltington (around 099 190) trends south-south-eastwards and has a downthrow of about 10m to the west-south-west; it extends beyond the eastern boundary of the sheet.

A strike fault on the northern limb of the Greenhurst Anticline is inferred beneath Head deposits masking the Fittleworth Beds. It extends for about 2km from north-north-east of Hurston Street Farm (0796 1607) to Champions Farm (0975 1645) and is confined within the Fittleworth Beds outcrop which, because of the faulting and also the steeper dip hereabouts, occupies a much narrower tract than usual. The displacement on this fault is difficult to estimate but is likely to be relatively small. Another fault, trending south-south-eastwards, intersects this one and follows the valley extending from near Threal's Farm (0949 1637) to Smock Alley (0885 1727). The downthrow on this cannot be less than 15m to the west-south-west, and the structure gives rise to two small outliers of Pulborough Sandrock that cap summits on the north-east side.

A fault aligned along the floor of the River Stor Valley has been traced from High Street, Storrington (0893 1425), to a point 750m to the north-west (0835 1486); the downthrow is estimated at 6m to the south-west.

5. DRIFT DEPOSITS

5.1 General Account

5.1.1 Clay-with-flints

Clay-with-flints, a residual deposit of stiff reddish-brown clay containing broken flints and flint nodules, occurs only in the extreme south-west corner of the sheet where it forms the northern extremity of a large spread resting on the Upper Chalk outcrop. Its thickness probably does not exceed 2m.

5.1.2 Head

Head includes a heterogeneous range of superficial deposits which have accumulated by downslope solifluction, under periglacial conditions, of weathered surface debris derived from a variety of lithological units. Soil creep and minor mass movements continue to add their contribution, especially on the dip slopes of the Hythe Beds where soliflucted material is banked against the upslope side of hedgerows.

The composition of these deposits reflects the range of source materials upslope. For example, material derived from the Fittleworth Beds is dominantly clayey; that from the Folkestone Beds is mainly sandy; and that from the Chalk contains much chalk debris and varying proportions of flints. In many cases it is almost impossible to distinguish Head satisfactorily from its parent body, particularly where it is derived from the Folkestone Beds. The thickness of Head is variable, but probably nowhere exceeds 3m.

The major period of Head formation appears to have taken place after the accumulation of the Third Terrace deposits which, together with material from higher terraces, contribute to extensive sheets of Head, particularly in more northerly parts.

These spreads of Head grade to the approximate level of the Second River Terrace deposits. Their relationship to the latter indicates that they pre-date them. The bulk of this Head probably corresponds to the older of the two sets of Head deposits described by Shephard-Thorn and others (1982, pp. 41-42) from the Arun Valley to the south of the present area which, at one locality, were seen to underlie Second Terrace gravelly sands (although the latter were assigned by those authors to the First Terrace). Because the Third River Terrace is probably broadly contemporaneous with the Brighton Raised Beach i.e. dating from the Ipswichian Interglacial (see 5.1.3), these Head deposits are most likely to be of Devensian age.

However, a proportion of the Head within the present area may be considerably older; this pertains particularly to the gravelly sands capping the Folkestone Beds ridge between Parham and Sullington which lie at elevations ranging from 45m to 65m O.D.

5.1.3 River Terrace Deposits

Flinty soil is present on the highest part of Hesworth Common (0050 1925), at an elevation of 70m O.D., i.e. some 64m above Alluvium level. Neither this deposit nor that at a lower level 150m to the south (0055 1910), which comprises up to 0.9m of angular carstone and flint debris overlying the Folkestone Beds, constitute a mappable deposit and they are not depicted separately on the 1:10 000 map.

Mapped deposits are assigned to seven river terraces ranging in elevation from just above floodplain level up to about 40m O.D. The Seventh River Terrace sediments are restricted to only one locality (060 162), near Wiggonholt. They comprise sand and dominantly flint gravel capping a small hill at a height of just over 40m O.D. Remnants of the Sixth River Terrace are also confined to the area between Wiggonholt and Parham; their base is at about 35m O.D., approximately 33m above the floodplain. Fifth Terrace sands and gravels are more widespread, and occur in close association with the older deposits as well as further west, near Greatham (around 040 153) and at Coates Common (000 176). The base of all the occurrences appears to be at c 27m O.D., that is about 25m above the floodplain.

The base of the Fourth Terrace is generally at c 15m O.D., about 13m above the Alluvium. However, towards the south, at Houghton (020 116), it is slightly lower at about 13m O.D. Locally the Fourth Terrace deposits form extensive flats, as at Hurston Warren (071 168). To the west of Glebe Farm (035 153) the sand and gravel has been extracted commercially. Chert is a common component of the Fourth Terrace spreads at the foot of the Hythe Beds dip-slope north of Stopham (030 195).

Third Terrace sands and gravels are widespread and have been worked in a number of pits in the past, notably around Hardham (033 173), but no sections remain. Sediments of the terrace are absent from the Arun Valley downstream from Wiggonholt until the river gap in the Chalk escarpment is reached, where there are two small spreads, at North Stoke (021 108) and South Stoke (026 100). In all the occurrences the base of the deposit is at about 10m O.D., some 8m or so above the Alluvium.

Second Terrace deposits have a surface elevation up to 5m above the Alluvium in the north, but only about 3m above the floodplain in the Arun Gap to the south. Upstream the deposits vary from quite flinty in some places to dominantly sandy in others. Locally, the deposits have been worked, for example 1.5km west-south-west of Greatham (028 156). To the south of this there are only three narrow strips of Second Terrace gravelly sands bordering the floodplain.

Deposits of the First Terrace have a surface elevation 0.5 to 1m above the Alluvium, the base being below the level of the floodplain. Nearly all are of quite limited extent, and the only spread of any size is on the north side of Amberley Wild Brooks (030 153). Here the terrace adjoins, and is partially overlain by peat. Ditch sections have revealed up to 1.5m of sand and gravel. There are no more First Terrace sediments downstream, presumably because their thalweg falls below the surface of the alluvial deposits.

There is no positive evidence for dating any of the river terrace deposits. The only guidance is given by Shephard-Thorn and others (1982, p. 22) who show that the Third River Terrace deposits are broadly contemporaneous with the formation of the wave-cut platform of the Brighton Raised Beach; the latter event is generally regarded as being of Ipswichian Interglacial age (Hodgson, 1964). If this is so, then the First and Second River Terrace sediments probably date from the Devensian stage, whereas the deposits of the Fourth and higher terraces are mainly of pre-Ipswichian age.

5.1.4 Alluvium

At the surface the Alluvium consists of stiff grey, or grey and brown clay. In boreholes this clay can be up to 10m thick and may include beds of peat; it commonly overlies a basal gravel unit which is up to 5m thick. It is certain that these alluvial strata contain an estuarine component. The River Arun is now tidal as far as Pallingham Lock (038 214), beyond the district, and the River Rother as far as Hardham (around 034 179). These rivers were presumably tidal above these points prior to the installation of locks and weirs. However, in the absence of any cored boreholes and palaeontological determinations of included flora or fauna, the estuarine component of Alluvium within this tract cannot be determined.

The Alluvium is probably wholly Holocene in age, although the deposition of the basal gravel may have been initiated in the late Pleistocene.

5.1.5 Peat

There are a number of peat occurrences on the margins of the River Rother and River Arun floodplain upstream from Amberley; thicknesses exceeding 1.2m are common. At the floodplain margin of the deposits, the peat is commonly overlain by alluvial clay. Towards the back margin, the peat generally rests on sands, of either solid formations or drift deposits. Much of the River Chilt floodplain (around 076 170) near West Chiltington is underlain by peat.

An extensive spread of peat covers the northern part of Amberley Wild Brooks (around 035 149) where up to 1.5m have been proved. The peat rests on gravelly sand, presumably of the First Terrace, at its northern margin; beyond its southern limit the peat can be traced intermittently as a thin bed below the topmost alluvial clays. Beds of peat at lower levels in the Alluvium sequence have also been proved in boreholes within the floodplain.

The Peat testifies to a period when a permanently water-logged fresh-water environment prevailed, probably during a slightly transgressive episode when the water table was raised. The approximate age of the surface peats is indicated by a radiocarbon date of 2620 ± 10 years B.P., from a peat overlying alluvial clay at a level of about 1.5m O.D. in Amberley Wild Brooks (0309 1413) (Shephard-Thorn, 1975, Table 1).

5.1.6 Landslip

Most of the slips in the northern part of the district originated by undercutting of the river cliffs by stream erosion. The largest of these slips, 500m north-west of Wiggonholt Farm (059 171), is in the Gault; it now appears to be stable as its toe is protected by a wide belt of Alluvium, whereas smaller slips affecting the Weald Clay (0835 1585) are still moving because of active stream erosion of their toes.

Two small slips north-north-east of Nutbourne affect the Atherfield Clay on the scarp face (081 196) beneath the Hythe Beds.

In the southern part of the area several landslips have occurred along the Upper Greensand/Gault junction; such landslips are characteristic of this boundary throughout the western Weald. These slips were presumably initiated by erosion at springs issuing from the base of the Upper Greensand, which over-steepened the slopes. Saturation and lubrication of joint and bedding surfaces in the superficial layers of the Gault, particularly when periglacial freeze-thaw conditions prevailed, then facilitated slipping.

These landslips are characterised by poorly drained hummocky ground, which is usually delimited downslope by a prominent toe that separates it from the smooth undisturbed

Gault surface beyond. Bold, steep slip-scars define the upper limit of these slips.

The major period of landslipping was presumably during the late Devensian stage, but the freshness of the toe feature in some places suggests that more recent movement has occurred. Structural damage to the house at Kithurst Farm (0787 1355) in historical times and recent movement of the walls of an outbuilding at the same locality indicates that this particular landslip, at least, is not yet stablised.

5.2 Local Details

5.2.1 Head

Springs issuing from the base of the Folkestone Beds are associated with extensive tracts (001 187, 004 188, 008 187) of dominantly sandy Head to the south-west of Fittleworth. To the north and east of the village Head, composed of sandy clay or clayey sand derived from the Hythe Beds and Fittleworth Beds, mantles all the valley sides and bottoms. Around Lee Farm (020 185) the Head consists of brown clayey sand with scattered flints and may in part represent a degraded terrace. Farther east, near Coldharbour (035 185), the slope between the Folkestone Beds and the River Terrace Deposits is mantled with brown clayey sand.

Most of the valleys draining off the Hythe Beds have a fill of clayey sand or sandy clay, which commonly occupies a narrow strip in the valley bottom. One valley immediately north of Pulborough (055 190), however, has a tract of Head up to 300m wide. Downslope movement of material derived from the Hythe Beds is still taking place as the surface levels on either side of hedgerows at right angles to the slope are markedly different.

Between Nutbourne and West Chillington spreads of Head consist for the most part of sandy clay. This appears to be derived principally from the Fittleworth Beds, but locally it has a component of fine-grained sand derived from the Pulborough Sandrock. The valley system between Smock Alley (around 092 168) and Champions Farm (098 165) is filled with clayey sand and sandy clay. Practically the whole length of Fittleworth Beds outcrop on the northern side of the Greenhurst Anticline is also hidden beneath similar deposits. In the core of the Anticline (around 087 157) the surface of the Weald Clay has an irregular cover of gravelly sandy clay up to 1.2m thick. In most cases it has been possible to auger through this Head and thus it has not been shown separately on the six-inch map.

In Northpark Wood (060 055), Parham, and at Washingham and Rackham commons, there are large low-lying boggy areas underlain by coarse-grained sand which is commonly organic and locally bleached white; it is derived from either the Folkestone Beds or River Terrace Deposits, or both.

Around Watersfield (02 16) most of the low-angled slopes are mantled with coarse-grained sand derived from the Folkestone Beds.

To the west of Coldwaltham (016 170, 022 170) tracts of clayey sand with some gravel probably represent degraded River Terrace Deposits. Springs commonly issue from the margin of this spread, as well as at undetermined horizons within the Head.

Horncroft Common (002 167) has a mantle of coarse-grained sand derived from the River Terrace Deposits, above the Gault; thicknesses locally exceed 1.5m.

Brown loamy silt and silty clay drapes the Gault outcrop below the Upper Greensand scarp south-south-west of Hale Hill

Farm (005 143), and east of Hollow Farm (015 137); they rest on a terrace-like bench overlying the Gault at the latter locality. The poorly drained valley slope near Timberley Farm (022 144) is covered by sandy gravelly Head derived from the Fourth River Terrace. Similar Head, but with a content of chalk detritus, veneers the slope separating Second and Fourth Terraces at Houghton (020 115).

East of the River Arun, at the foot of the old river cliff cut in Upper Greensand at the southern margin of Amberley Wild Brooks, a narrow strip of Head consisting of brown silty loam containing malmstone fragments separates the cliff from the floodplain alluvium.

At Parham Park and at Cootham, small tongues and irregular patches of coarse sand drape the margins of the Folkestone Beds ridge, where they give rise to poorly drained, boggy ground. A ditch section at Cootham (0725 1443) revealed 1.2m of Head overlying the Marehill Clay, the former comprising 0.6m of dark brown, coarse-grained sand with a few small flints, overlying 0.6m of orange and greenish-grey mottled loamy sand which becomes very clayey and slightly flinty towards the base.

Tongues of Head in the floors of shallow valleys draining the Folkestone Beds at Storrington (c 088 141) consist of slightly gravelly, coarse-grained sand containing flints and malmstone fragments. A spread of dark brown, coarse-grained slightly flinty sand which occupies the poorly drained slopes on the north-east side of Sullington Warren is derived in part from recycled higher-level flinty Head.

Head deposits in the floor of the valley draining north to Cootham from near Pay Gate (0723 1370 - 0741 1390) consist of dark brown sandy loam containing a few small flints (up to 0.8m), overlying coarse gravel with a loamy sand matrix (up to 0.4m), comprising abundant small angular flints, large nodular flints and some malmstone fragments. Beyond the Gault outcrop 'Iron grit' fragments are also included.

Patches of high level, gravelly, fine- to coarse-grained sand containing angular and sub-angular, white-patinated flints cap the Folkestone Beds ridge at intervals between Parham and Sullington Warren. They stand at elevations ranging from c 45m to c 65m O.D. Their topographical position, variable height and exclusively flint content suggest that they are Head deposits rather than high-level river terrace sediments. They are probably considerably older than other Head deposits in the district.

Head deposits which occupy the floors of flattish-bottomed dry valleys on the South Downs dipslope comprise long narrow strips of buff marly loam containing sub-rounded, fine to coarse chalk rubble and many flints. The topmost 1m or so is commonly decalcified to give a dark brown, flinty, non-chalky loam.

In the dry valleys of the north-facing Chalk scarp there are similar marly chalky loams in which, however, flints are far less numerous, reflecting the largely non-flinty source material of Lower and Middle Chalk. Towards the heads of the dry valleys the deposits are dominantly composed of chalk rubble. Where the valleys impinge on the Upper Greensand and Gault outcrops the Head deposits correspondingly change to silty loams and loamy clays with fragments of malmstone, few flints and much less chalk detritus.

Sections in the valley fill at Bury Manor Farm (0075 1308) reveal up to 1.4m of fawn shelly marl containing much sub-rounded chalk rubble and a few scattered flints. The shells comprise a variety of terrestrial gastropods. In the bank of the entrance footpath to Chalk Pits Museum (0277 1191), 1.5m of unbedded, pale brown, marly silty loam with much chalk debris is exposed. Some 470m to the north-east (0315 1220) the southern face of the abandoned chalk pit shows brown loamy soil, 0.3m, resting on unbedded, poorly sorted, greyish-brown, chalky silty loam containing sub-rounded chalk rubble up to 10mm grade, 1.7m; the latter is slightly piped unto the underlying buff chalky marl which contains a smaller quantity of chalk rubble, picking out a crude bedding; the base is festooned into weathered marly chalk below, indicating a phase of frost-heaving subsequent to deposition.

Immediately east of Amberley the deposits of three dry valleys on the chalk scarp merge into a broad spread of Head in the floor of a depression (038 132). Ditches revealed 0.7m - 1.1m of dark brown silty clay loam containing malmstone fragments, scattered chalk pellets and sporadic small flints resting on Upper Greensand at the eastern end of the depression (041 132). Elsewhere, up to 0.4m of either green glauconitic loamy sand, derived from the Glauconitic Marl, or marly chalk rubble was seen below an average of 0.8m of dark brown loam.

5.2.2 River Terrace Deposits

5.2.2.1 Sixth River Terrace Deposits

To the south of Wiggonholt Farm the south-eastward trending ridge (064 161) is covered with flinty gravelly sand. Spreads of sand and gravel at similar heights cap low hills in Northpark Wood (057 157 and 060 153). Bleached angular flints are common on the surface of the latter deposit. Another outcrop of medium-grained sand with scattered flints occurs just east of Parham Farm (066 143), where its thickness is probably no greater than 2m.

5.2.2.2 Fifth River Terrace Deposits

A small spread of 5th River Terrace Deposits occurs within the present district 300m south of Coates Farm (000 176) This is part of a more extensive spread to the west which covers much of Sutton Common. A section in the Coates Sandpit (SU 998 176) showed:

	Thickness m
5th River Terrace Deposits	
Sand, flinty	0.5
Clay, sandy, mottled orange and grey, passing down into grey clay	0.3
Sand, flinty, orange, lenticular	0.1-0.4
Sand and gravel, cross-bedded, poorly sorted, with angular flints	0.1-1.5
Folkestone Beds	
Sand, fine-, medium-, coarse-grained, cross-bedded	15+ seen

To the north of Horncroft Common (005 170) the surface of the Gault is covered with medium- to coarse-grained sand; only locally is the deposit flinty. Springs occur in places at the junction with the Gault. Clayey sand in excess of 1.4m, locally gravelly, is present over the Gault to the south (012 168) and east (016 168) of Coldwaltham Farm.

Sand and gravel caps the low hill (051 154) on Sparrite Common. In Northpark Wood another low rise (0650 1535) has a covering of medium- to coarse-grained sand with scattered flints. Bog Common (068 155) to the north-east also has a spread of dominantly coarse-grained sand on its surface. A more extensive tract of sand and gravel which occurs near Wiggonholt (062 164) consists, for the most part, of coarse-grained sand with scattered flints. Thicknesses up to 2.7m have been proved. A more gravelly patch can be found to the south-west of Upperton Barn (0575 1635). Small gravelly patches are present to the north-west of Glebe Farm (037 156 and 038 154).

Three outcrops of gravelly sand cap the Folkestone Beds ridge at and to the weet of Parham House (0600 1420). The largest, on which the house stands, occupies a bench sloping gently to the north. Small exposures 50m south (0604 1414) and 340m west (0563 1425) of the building showed up to 1m of brown, coarse-grained sand containing scattered small angular flints, resting on Folkestone Beds.

5.2.2.3 Fourth River Terrace Deposits

A large tract of clayey coarse-grained sand with only minor amounts of gravel is present around Tripphill (006 176). Springs are a common feature at the base of the deposit, especially on the east.

To the north of Stopham there are three small spreads (0275 1918, 027 193 and 0303 1965) of sand and gravel. At the last locality there is much chert debris in the soil.

Hurston Warren Golf Club is situated on the broad flat of the Fourth River Terrace Deposits on the interfluve between the rivers Chilt and Stor. Sand and gravel are consistently augered over this tract, but the thickness is not thought to be great, as in one borehole (0732 1677) only 1.2m of 'sand and flint' was proved. Shallow pits (069 173) farther north-west possibly indicate thicker deposits. On the opposite side of the River Stor, south-west of Hurston Place Farm, clayey sand and gravel can be found in two small areas (070 160 and 068 158). Farther west a very gravelly patch (056 163) is present to the south-west of Upperton Barn, and 300m to the south of this (056 161) there is a less gravelly deposit.

Sand and gravel hss been extracted from an old pit (035 153) to the east of Glebe Farm. Between here and Quell Farm a more extensive area of sand and gravel occurs (033 157). Springs issue from the base of this deposit where it overlies the Marehill Clay.

Downstream, Fourth Terrace gravel caps the flat-topped hill at Timberley Farm (021 142). A former section in the railway cutting here (0215 1425) exposed 2.7m of stratified gravel with loamy and ferruginous sand at the top, overlying Gault clay; the gravel comprised sub-angular flint, ironstone and sandstone fragments. Further south, at Houghton (020 116), poor exposures in the road verge show coarse sandy gravel containing abundant nodular and sub-angular flints, sporadic ironstone pebbles and sub-rounded fragments of slightly glauconitic fine-grained sandstone (of Hythe Beds aspect).

5.2.2.4 Third River Terrace Deposits

The Third River Terrace Deposits give rise to quite extensive flats on the south side of the River Rother and, below the confluence with the River Arun, on both sides of this latter river.

Spreads of Third Terrace Deposits (014 177 and 017 174) to the east of Tripphill appear to consist of clayey sand and gravel. Locally there are springs at the base of these deposits.

At Coldwaltham the Third River Terrace Deposits are locally divisible into two leaves, the upper (026 168) being some 0.5 to 1.0m higher than the lower. The lower extends from here to just beyond St. Botolph's Church, Hardham (040 176). Springs are common nearly all the way around the deposit where it rests on Gault. In the pit 150m east of Hardham Priory (035 171), coarse-grained sand and poorly sorted gravel can still be seen at the top. Another pit 400m to the north-west (0324 1735) is about 1.5m deep and boggy in the base; this last feature presumably indicates proximity to the Gault. Up to 2m of sand and gravel were noted in the Hardham Waterworks excavations (0349 1767). Some 70m south-east of this point 2.5m of gritty clayey sand and gravel were proved in a borehole (0354 1764).

A borehole (0515 1764) east of St. Botolph's Church passed through 3.04m of dark brown sandy soil with pebbles before entering the Folkestone Beds. On the opposite side of the river (054 170) the terrace deposits appear to consist of medium- and coarse-grained clayey sand. About 1m of sand and gravel above Folkestone Beds was augered close to an old pit (0658 1710) 150m south-east of Wiggonholt Farm. At a former sandpit 170m to the east (0673 1712), on the east side of the River Chilt, 1m of sand with flints is still exposed above the Folkestone Beds.

Downstream, Greatham Church stands on a broad, partially dissected terrace flat. The deposits here appear to be dominantly gravelly and give rise to springs at the base where they rest on Marehill Clay or Fittleworth Beds.

In the Arun Gap, south of Amberley Station, there are two small spreads of sand and gravel which occupy gently sloping benches in the meander cores at North Stoke (021 108) and South Stoke (026 100). Old workings in the former are now grassed over and only sandy gravelly soil betrays the presence of terrace gravel.

5.2.2.5 Second River Terrace Deposits

Locally (0175 1830), 300m south-west of Lee Farm, Fittleworth, the Second Terrace deposits which border the River Rother are very flinty, but elsewhere they are composed of fine- to medium-grained sand.

The Second Terrace Deposits, whose thickness probably does not exceed 1.2m, form a broad flat on the interfluve between the rivers Stor and Arun. Near the Nursery (070 177) at Nutbourne Common there are many glauconitic sandstone pebbles on the terrace surface of the River Chilt.

In the Arun Valley a face in the eastern corner (030 155) of a disused pit south-west of Quell's Farm, near Greatham, reveals about 1.5m of sand and sandy gravel at the top, with a coarse-grained sand of the Folkestone Beds at the bottom.

Further downstream, a narrow outcrop (023 139) borders the floodplain 300m south-east of Timberley Farm; up to 1.2m of fine-grained sand containing only a little gravel was augered.

In the Arun Gap, narrow arcuate strips of gravelly sand margin the floodplain alluvium at the lower extremities of the meander slip off slopes at Houghton (022 116), North Stoke (019 107) and South Stoke (027 100). In all three localities rusty brown, medium-grained gravelly sand can be augered.

5.2.3 Alluvium

Most of the surface Alluvium in all districts consists of stiff grey or grey and brown clay.

A line of boreholes across the floodplain of the River Arun at Stopham Bridge (029 185) proved alluvial clay overlying gravel, together totalling 15m. One borehole (0297 1845) passed through the following sequence:

	Thickness m	Depth m
Alluvial Clay		
Clay, greyish brown mottled, with some peat	3.0	3.0
Clay, greyish blue, very soft, with peat	4.5	7.5
Clay, blue, soft	0.5	8.0
Clay, silty, brown, soft, with a trace of sand	2.0	10.0
Gravel, with coarse sand and clay layers	5.0	15.0
Pulborough Sandrock?		
Sand, compact, brown	1.0	16.0
Sand, compact, bluish green	3.0	19.0

A temporary exposure (0344 1798) near Hardham Mill showed 1.6m of grey sandy clay which thinned rapidly eastwards to 0.6m, resting on 0.4m of organic-rich, dark greyish brown sandy clay with rootlets, above 2.0m of sand and some gravel, which rests on the Folkestone Beds. Further downstream an exposure (0426 1830) revealed 0.9m of stiff brown and grey clay above 1.0m of soft, grey organic clay. Farther east, in the water meadows (051 178) to the south of Pulborough, the alluvial clay, from 0.5 to 1.2m in thickness, can be seen to overlap the River Terrace sands.

To the east of Coldwaltham the alluvial deposits totalled 12.8m and 14.02m in two boreholes (0344 1665 and 0341 1685). The log of the southernmost borehole is as follows:

	Thickness m	Depth m
Topsoil	0.30	0.30

	Thickness m	Depth m
Brought forward	-	0.30
Alluvium		
Clay, mottled brown and grey	0.77	1.07
Clay, highly plastic, brownish grey	1.98	3.05
Peat	5.18	8.23
Clay, light grey	0.30	8.53
Clay, silty	0.46	8.99
Sand	0.98	9.91
Clay and gravel	0.15	10.06
Gravel	3.96	14.02
Gault		
Blue Clay	26.42	40.44

Several boreholes have penetrated the alluvial sediments of Amberley Wild Brooks, the greatest proved thickness being in the one (0415 1404) 650m west of Rackham House. The following was recorded:

	Thickness m	Depth m
Grey and brown mottled silty clay	0.7	0.7
Peat	0.5	1.2
Soft blue-grey silt	0.4	1.6
Dark grey peaty silt	0.6	2.2
Dark grey silt	1.3	3.5
Grey sand and silty sand, with clayey bands	8.5	12.0

Logs of boreholes adjacent to Ham Sluice (0300 1405) show a considerable variation in Alluvium thickness. Thus, a borehole (0310 1417) penetrated 10.5m of Alluvium comprising 1.3m of grey and brown silty clays resting on 9.2m of silt and silty sand (unbottomed). Another borehole (c 0300 1405) 150m to the south-west, proved only 5.3m of Alluvium overlying Gault, the former consisting of interbedded clay, silt and sand with some shingle at the base. The sequence recorded at a site 350m to the south (0306 1367) is as follows:

	Thickness m	Depth m
Brown, grey and orange silty clay	1.3	1.3
Grey and brown silt with peat	3.1	4.4
Grey sand and clayey sand	2.6	7.0
Grey silty clay with peat traces	0.8	7.8
Grey silt with peat traces	4.4	12.2

5.2.4 Peat

On the south side of the River Rother (010 181), near Fittleworth, there is an area of peat overlying sand. The peat was proved to exceed 1.2m in the east, but in the west the thickness varied from 0.3 to 1.1m.

About 0.5km to the east peat occurs on the north side of the river (015 181). Towards the back margin the peat varies in thickness between 0.2 and 0.6m and overlies sand, whereas towards the river there is up to 1m of alluvial clay overlying the peat.

A few hundred metres downstream there is a more extensive area of peat (020 181), which mostly exceeds 1.2m in thickness and also locally rests on sand. It is, in turn, partially overlain by alluvial clay, mainly along the margin of the deposit.

Peat is encountered along the River Arun, about 700m upstream from its confluence with the River Rother (030 187).

In places the peat exceeds 1.2m in thickness; elsewhere there is up to 0.7m of alluvial clay or downwashed sand over an unknown thickness of peat. Farther downstream there is a belt of peat up to 80m wide in the back of the old meander loop to the north of Wiggonholt (061 174). The peat here mostly exceeds 1.2m in thickness and is locally overlain by alluvial clay.

Continuing southwards down the River Arun there is a kilometre-long tract in the back of the old meander to the south-west of Wiggonholt (050 161). In the east the peat varies in thickness between 0.5 and 1.2m and overlies sand; in the west the peat exceeds 1.2m in thickness, but is partially overlain by alluvial clay.

Just north of Hardham Priory, two boreholes (0341 1685 and 0344 1665) drilled through the Alluvium proved thicknesses of 5.18m of peat, and 5.18m of clay and peat, beneath 3.05m and 6.09m of Alluvium respectively.

The northern part of Amberley Wild Brooks is underlain by peat. In many areas it is quite thin (up to 0.7m) but there are several irregular, well-defined, elevated tracts whose surface level is a metre or so higher than elsewhere. In these the thickness of peat is at least 1.2m and a maximum of 1.5m has been recorded. Locally, there is evidence to show that the peat extends to the south as a thin impersistent bed at shallow depth below the most recent of the alluvial clays. The main body of the peat usually rests on grey alluvial clay and, locally, on grey silt. However, towards the northern margin it is underlain by sand. Up to 1.5m of peat was seen to overlie slightly gravelly, medium-grained sand in ditches 1km north-east of Timberley Farm (027 148).

Much of the floodplain of the River Chilt is occupied by a boggy tract of peat which exceeds 1.2m in thickness. Towards the margin of the tract the peat rests on sand.

5.2.5 Landslip

A small slip (0085 1580) about 70m across occurs on the steep slope of the Gault at Tuppers Copse. A much more extensive slip, some 500m long and also affecting the Gault, can be found to the north of Wiggonholt (059 171). Here slipping has taken place on the steep old river cliff. Now that the toe is no longer being actively eroded it is presumed that the slope is fairly stable.

On the northern margin of the district two small slips (081 196 and 0815 1970) adjacent to Crowell Farm affect the Atherfield Clay and basal Hythe Beds. Here the movement is related to the springs issuing from the base of the Hythe Beds.

Farther south, to the east of Hurston Street Farm, an area of instability (0835 1535) affects mostly the Weald Clay. The movement here is caused by stream erosion at the foot of the steep slope. As the toe of the cliff is still being eroded, continuing movement of this ground can be expected.

About 1km north-west of Bury there is a major landslip at the Upper Greensand/Gault boundary (002 148); it extends for some distance westwards onto the adjoining SU 91 SE sheet. The slip appears to be composite; it includes several smaller ones and gives rise to badly drained hummocky ground delimited by a prominent slip scar at the back and by a bold, fresh-looking toe downslope. From the base of the toe feature numerous springs issue. At Fletchers Grevatts (1515 1490) a fan-shaped mud flow extends for about 150m from the foot of the hummocky slope. It is probable that this landslip is still inherently unstable.

East of the River Arun, at Amberley, a much smaller patch of hummocky landslip below the Upper Greensand/Gault boundary (043 137) displays a more mature topography. A little to the west, two small discrete masses of Upper Greensand have fallen from the old river cliff at the southern margin of the Wild Brooks (038 134); large blocks of malmstone can be seen at the surface.

To the east of Rackham, landslips associated with the Greensand/Gault junction occur just north of Springhead Farm (060 136) and at Kithurst Farm (078 135). The latter is still unstable, judging by recent movement in the foundations of an outbuilding and a fresh slip scar in Gault Clay a little upslope from it.

6. HYDROGEOLOGY

6.1 Surface hydrology

The surface drainage of the area is concentrated mainly in the principal rivers, the Arun and the Rother. The former rises in the central Weald and flows southwards for the most part as a down-dip consequent, breaching the South Downs escarpment in one of its major river gaps. The subsequent River Rother rises in the western Weald, north of Petersfield, and drains east-south-eastwards mostly along the outcrop of the Sandgate Beds, but also partly on the Folkestone Beds in the lower reaches up to its confluence with the River Arun at Hardham. The chief tributaries are the River Stor and River Chilt which drain the area north of the Chalk scarp, to the east of the River Arun. Surface water abstraction for public supply takes place at Hardham Pumping Station (0323 1775) just above the limit of tidal saline contamination on the River Rother.

The dip slope of the Chalk escarpment is characterised by many dry valleys, most descending the dip slope to the Sussex Coastal Plain, but some falling to the Arun river gap. They lie well above the present water table and may be regarded as fossil landscape features formed during a past period of enhanced run-off in a periglacial regime, or a time of higher water table reflecting a wetter climate.

6.2 Groundwater hydrgeology

The three principal aquifers within the district are the Hythe Beds, Folkestone Beds and Chalk/Upper Greensand. Locally the River Terrace Deposits provide a limited source of water. Each of the three major aquifers is in hydraulic isolation, with the Marehill Clay and the Gault aquicludes effectively sealing the Folkestone Beds from the Hythe Beds below and the Chalk/Upper Greensand above.

The Hythe Beds dip-slope, 1-2km in width, affords an extensive catchment, and the formation is underlain by impervious Atherfield Clay at the contact with which there is a prominent spring line. As an aquifer, however, the formation has limitations because many of the sandstones are cemented and non-porous, and act as barriers to the vertical movement of water. Finer-grained, silty and argillaceous horizons also inhibit free circulation, giving rise to perched water levels. Abstraction of water from this formation is thus determined largely by the incidence of fissures within the sandstones. Of the three major aquifers the Hythe Beds is the least satisfactory in terms of available resources.

The Folkestone Beds, which comprise mainly free-draining sands ranging from 44m to 71m in thickness within the present area, form a more important aquifer. Their general lack of cement, coarse grain size and lack of 'fines' are significant factors in promoting good circulation of groundwater, and their structural position within the Wiggonholt Syncline makes them an ideal reservoir (Fig. 3) Initial experiments by the Southern Water Authority during the period 1968-1975 into recharging this aquifer with surplus winter flow from the River Rother, which at the moment provides the principal source of water for the whole of West Sussex (approximately two-thirds of its current supply), indicated that a demand of up to 33 million gallons a day, using both the recharged aquifer and river, could be satisfied. To this end trial recharge lagoons were built in the floodplain of the Rother at Hardham. However, since these early studies, a computer-simulated model of the Folkestone Beds aquifer suggests that demand in the foreseeable future could be met by natural recharge, together with the continuing abstraction from the River Rother.

The Chalk and Upper Greensand are important sources of water, both from springs and from boreholes. The hydrogeology of the aquifer has been considered by Whitaker (1911), Edmunds (1928) and Gray and Day (1958), from whose accounts much of the following has been paraphrased.

The aquifer has a very large catchment area, the most significant portion of which is the dip slope of the South Downs. Almost all the rain falling on this ground, apart from a percentage lost by evaporation, infiltrates the Chalk directly because there is practically no surface run-off. The average annual rainfall on the part of the Downs within the present area is about 950mm, the greater part of which falls during the winter months. The hydrograph of a typical Chalk well shown on the hydrogeological map of the South Downs (IGS, 1978) illustrates the fairly rapid response of groundwater level to winter rainfall. This rapid response is characteristic of fissure-flow aquifers.

The Chalk is a fine-grained, compact sediment with a low hydraulic conductivity and a high resistance to water abstraction. The copious quantities of groundwater yielded by the Chalk is thus derived from fissures, joints and bedding planes, which wells must intercept to ensure supplies. Indeed, many wells have horizontal adits extending from the vertical shaft in order to increase the number of water-bearing fissures tapped. Closure of fissures at depth restricts the level from which groundwater can be abstracted from within the Chalk to a maximum of about 150m below surface level. Together with the limitations of water supply from the Upper Greensand, this means that groundwater abstraction is largely from the Upper and Middle Chalk. The restricted resources of the Upper Greensand result from its own limited catchment area and its partial isolation from the main groundwater reservoir of the Chalk by the relatively impervious marly strata of the Lower Chalk.

The water table in the Chalk more or less parallels the surface contours, with the highest level approximating to the watershed of the South Downs. Groundwater flow from the highest point is partly northwards towards the scarp face, at the foot of which it issues in surface springs; these commonly arise at the Chalk/Upper Greensand boundary (from the Glauconitic Marl), but also locally from higher levels in the Lower Chalk. The remainder of the circulating groundwater in the aquifer drains southwards and, ultimately, issues at springs to the south of the present area which feed streams crossing the Sussex Coastal Plain. Seasonal fluctuations in the water table level can be as much as about 45m and peak summer demand relies on good winter rainfall to replenish supplies and maintain groundwater levels.

The groundwater from the Chalk is hard but of good quality. However, wells close to the tidal reach of the River Arun flood-plain are subject to saline contamination from percolating seawater.

As mentioned above, River Terrace Deposits provide only a limited and localised supply of water. Their main interest lies in the fact that where they overlie impervious formations such as the Gault and Fittleworth Beds they may support perched water tables; thus any potential extraction of sand and gravel may encounter saturated sediments at relatively shallow depths.

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APPENDIX I: FAUNAS OF THE PULBOROUGH SANDROCK
(by A. A. Mortimer)

1. Introduction

The 1" 317 Chichester sheet includes some classic fossiliferous localities, some of which were extensively collected last century. The faunas are contained in ironstone nodules in the higher part of the Sandgate Beds (Lower Greensand).

The famous locality of Parham Park (0535 1525) was described by Mantell (1822, pp. 71-72; 1829, pp. 211-212), Martin (1827; 1828), and Fitton (1836, pp..157-9).

Other notable localities were June Lane, Midhurst (SU 8810 2095); Park Lane, Pulborough (0394 1895); Muttons Farm near Ashington, and near Rogate, Sussex (see Casey 1961, p. 557). No collections exist in IGS for Muttons Farm (but see Kirkaldy 1937); the fauna of the Rogate locality, near Habin Bridge (SU 8092 2298) has already been described in Palaeontology Department Report 81/70.

Casey (1961, p. 557) revised the nomenclature of the mollusc fauna from these fossiliferous ironstone nodules, but did not give individual lists for each locality.

It is noteworthy that the more abundant shells are found in all the localities, but rarer fossils may be confined to only one or two localities. The distribution of latter may be a result of local palaeoecological controls.

The faunas from most sites mentioned above have been re-examined and more detailed faunal lists compiled. The exceptions to this are the Kirkaldy collection (see Kirkaldy 1937), and the records (mainly from Parham) based on the Mantell collection in the British Museum, Natural History. This report is based on the Martin collection (Geol. Soc. Lond. collection) in IGS, and material collected by Topley, Lamplugh, and recently by Dr. C.R. Bristow for the Geological Survey, all housed in IGS.

2. Localities

(a). Parham Park (0535 1525)

Mantell (1822, pp. 71-74) first described this locality as a section "immediately below the turf of Parham Park"; 17 fossils were listed.

Martin (1827; 1828) and Fitton (1836) listed fossils based on the collection of Martin, presented to the Geological Survey in 1911 but now contained in the Geological Society's collection. The latter is numbered in the Geological Society's Museum Series nos. 2036-2294 (not inclusive) and GSd 5218-5370 (not inclusive). Kirkaldy (1937) examined part of this collection.

The fossiliferous ironstone nodules from Parham Park contain the following:

Bivalvia

- Ceratostreon tuburculiferum (Koch & Dunker) common
- Gervillia (G.) forbesiana (d'Orbigny)
- Limatula dupiniana (d'Orbigny)
- Lycettia lanceolatus (J. de C. Sowerby)
- Mesolinga? cornueliana (d'Orbigny)
- Modiolus aequalis J. Sowerby
- Nucula (Leionucula) cf. albensis (d'Orbigny)
- 'Nucula' meyeri Gardner
- Oxytoma pectinatum (J. de C. Sowerby)
- Palaeomoera inaequalis (J. de C. Sowerby)
- Panopea plicata (J. de C. Sowerby)
- Parmicorbula striatula (J. de C Sowerby) abundant
- Phelopteria cf. rostrata (J. de C. Sowerby)
- Pinna robinaldina d'Orbigny
- Pleuriocardia sp.
- Pterotrigonia mantelli Casey
- Resatrix (R.) parva (J. de C. Sowerby) common
- Senis wharburtoni (Forbes)

Thetis minor J. de C. Sowerby

Toucasia lonsdalei (J. de C. Sowerby)

Venilicardia sowerbyi Woods

A record of Pecten (Syncyclonema) orbicularis (J. Sow) in Woods (1899-1903) is of doubtful provenance. The record is based on the Mantell collection, where Mantell (1829, p. 212, footnote e) notes 'upper valve? A flat shell with numerous striae.' No Entolium have been observed by the author from the ironstone nodules of the Sandgate Beds, e.g. Dhondt (1971) does not cite Parham as a locality for Entolium orbiculare.

(b). Park Lane, Pulborough (0396 1897)

The following fauna has been collected from fossiliferous ironstone nodules at Park Lane near Pulborough, Sussex, by Topley (1875, p. 137) (Registered Nos. Zr 1850-1890), Kirkaldy (1937) (collection not examined) and Dr. C.R. Bristow (BRI 1522-1542).

(Topley = T, Kirkaldy = K, and Bristow = B).

Annellida	Parsimonia cf. antiquata (J. de C. Sowerby) B
Brachiopoda	'Rynchonella' sp. K
Bivalvia	Anthonya cantiana Woods B
	cf. Arca dupiniana d'Orbigny B
	Astarte sp.
	'Chlamys' cf. elongatus (Lamarck) K
	Cucullaea cornueliana (d'Orb) K
	Gervillella sublanceolata (d'Orb) B, K
	Inoceramus sp. K
	Linearia sp. K
	Lycettia lanceolata (J. de C. Sowerby) K
	Mimachlamys cf. robinaldina (d'Orb) B, K
	Modiolus aequalis J. Sowerby K

Nucula (Leionucula) cf. albensis (d'Orb) K

Nucula (Pectinucula) cf. arduenensis (d'Orb) B

Panopea plicata (J. de C. Sowerby) K

Parmicorbula striatula (J. de C. Sowerby) T, K, B

Pinna sp. K

Pleuriocardia sp. Cardium sp. K

Resatrix (R.) parva (J. de C. Sowerby) T, K, B

Senis wharburtoni (Forbes) K

Thetis minor J. de C. Sowerby K

Venilicardia sowerbyi Woods K

" sp. aff. sowerbyi T

" sp. B

Gastropoda Anchura (Perissoptera) cf. parkinsoni (Mantell) T

" " robinaldina (d'Orb) T, K

" " sp. B

Atresius fittoni (d'Orbigny) T

Bathraspira shanklinensis Abbas T

Gyrodes cf. gentii (J. Sow) T

'Nerinea' sp. nov. B

Neritopsoides cf. ous (Wollemann) T (det. Dr. N. Morris, R. Cleevley BM (NH)

Ovactaeonina forbesiana (d'Orbigny) B

Ringinella subalbensis (d'Orbigny) T

Tornatellaea cf. aptiensis (Pictet & Campiche) T

A few new records have been discovered, notably Anthonya and Nucula (Pentinucula), which provide faunal links with the type area of the Sandgate Beds in Kent. A few gastropods are recorded for the first time following the work of Abbas (1973) and current work by my colleagues in the BM(NH) mollusc section. A revision of Cretaceous gastropods is currently being undertaken by them.

3. Conclusions

The faunas of the fossiliferous ironstone nodules from the Sandgate Beds, Pulborough Sandrock, generally include abundant shells which are common to all the localities examined. Individual localities appear to differ in the shell content of rarer species, probably reflecting differing local conditions of the palaeonenvironment, or slightly different stratigraphical levels.

Almost all species, however, occur in the Seend Ironsand of Wiltshire or the ironstone nodules of Group XIV, Shanklin, Isle of Wight, all regarded by Casey (1961) as of Parahoplites nutfieldiensis Zone age, P. cunningtoni Subzone of the late Aptian.

APPENDIX II: FAUNA FROM THE LOWER CHALK, NEAR AMBERLEY
(by C. J. Wood)

1. Palaeontology

Twenty-three Lower Chalk macrofossils (registered RJ 1467-1489) were collected from field brash at a point 600m west-south-west of Amberley Church, Sussex (0230 1295) from an horizon near the base of the Lower Chalk. As the collection was made from brash on the surface of a sloping field, it cannot strictly be regarded as a single strata-graphically restricted assemblage. However, it probably comes from a relatively restricted succession and, with that proviso, it can be treated as a broad assemblage. The majority of the fossils are preserved as relatively undistorted three-dimensional moulds, in hard grey muddy limestones, but the inoceramid bivalves retain small portions of shell. The assemblage largely comprises ammonites (predoninantly Schloenbachia) together with three inoceramid bivalves and other indeterminate bivalves, a small single coral and a crab appendage. The list of determinations is as follows:

Anthozoa (corals): Prototrochocyathus? det. by A.A. Morter

Bivalvia: indeterminate without better comparative material, but possibly including a _Cucullaea_ sp. juv. or related genus, to judge from style of ornament.

'_Inoceramus_' ex gr. _crippsi_ Mantell, including one juvenile (RJ 1488) with coarse, regularly spaced rugae very close to '_I.' crippsi crippsi_ and a third form (RJ 1487), only questionably assigned to this species-group.

Ammonoidea: _Hyphoplites falcatus_ (Mantell)

_H._ aff. _crassofalcatus_ (Semenow)

Hypoturrilites tuberculatus (Bosc)

Mantelliceras tuberculatum (Mantell)

_M._ sp.

Schloenbachia varians (J. Sowerby)

ventriosa Stieler, _varians_ s.s., _subtuberculata_ (Sharpe), _subvarians_ Spath and _subplana_ (Mantell), in decreasing degree of inflation and strength of tuberculation.

Stomohamites sp. (nov.?) with relatively coarse rounded ribs

Arthropoda: carpus (wrist) of a crab, possibly dromiacean, but not otherwise determinable at present (RJ 1481); preserved inside the body chamber of a _Schloenbachia varians_. Determination by S.F. Morris, British Museum (Natural Histroy)

2. Notes on the determinations

(a) The questionable _Prototrochocyathus_ (RJ 1489) is an interesting record. The genus is known from the Gault and Cambridge Greensand, and there are records of '_Trochocyathus_' from the Lower Chalk, but very little is known about the speciation and stratigraphical distribution of this group. The specimen in question is a small calyx with granulate exsert septa; the septa inside the calyx were not preserved and in consequence the generic assignment is suggested on the basis of external morphology only.

(b) There is some controversy amongst ammonite specialists whether Hyphoplites crassofalcatus should be recognised as an independent species, or whether it should be included within the synonomy of H. arausionensis (Herbert & Munier-Chalmas). My preference is to accept H. crassofalcatus as distinct, and this is followed here.

(c) Modern practice is to regard Schloenbachia as a genus exhibiting extreme morphological variation within a population, the variation ranging from inflated coarsely tuberculate (hypernodose) forms to compressed virtually smooth forms. Lower Cenomanian Schloenbachia are referred to S. varians, this being the appropriate name in the case of the present assemblage.

3. Biostratigraphy

The presence of the ammonite genera Hyphoplites and Mantelliceras means that the assemblage can be referred without question to the Lower Cenomanian. The absence of the distinctive non-tuberculate Mantelliceras ex gr. dixoni Spath-orbignyi (Collignon) means that the upper (Mantelliceras orbignyi Zone) can be excluded, which leaves the broad Mantelliceras mantelli Zone by elimination. The mantelli Zone is divided into a lower Neostlingoceras (Hypoturrilites) carcitanense Subzone, particularly characterised by the heteromorph genera Anisoceras and Idiohamites; and a higher Mantelliceras saxbii Zone, in which these heteromorphs are virtually absent. The assemblage is, strictly speaking, not sufficiently extensive to support reference unequivocally to one subzone rather than another, but the absence of Idiohamites sp., taken together with the occurrence of *Hyphoplites falcatus*, which is locally common in the *saxbii* Subzone, tends to favour assignment to that subzone. On the other hand, and perhaps more significantly, the coarsely tuberculate inflated *Mantelliceras tuberculatus* and the absence of compressed *Mantelliceras* ex gr. *saxbii* (Sharpe), suggest a lower horizon, i.e. the *carcitanense* Subzone, an indication supported by the relatively low stratigraphical level. The assemblage is, in fact, not dissimilar to that described by Kennedy (1969, pp. 496-497) from a temporary section, supposedly in the *carcitanense* Subzone, near Upper Beeding (TQ 211 114) which exposed a band of hard calcareous concretions about 3m above the base of the Chalk; this Upper Beeding assemblage was characterised by inflated *Mantelliceras* and abundant *Schloenbachia varians*, but neither *Anisoceras* nor *Idiohamites* was recorded. The preservation of the fossils at Upper Beeding was described as remarkable in that some of the *Schloenbachia* retained their apertures, and spines were present on the *Hypoturrilites*; the preservation of the Amberley assemblage is also much better than average, and outstanding in the case of the crab carpus and one of the inoceramids.

4. Lithostratigraphy

The stratigraphical level falls low in the Chalk Marl, but the absence of glauconite grains precludes an horizon immediately above the Glauconitic Marl. The lower part of the Chalk Marl in the adjacent railway cutting is described by Reid, *in* Jukes-Browne & Hill (1903, p. 66), as a sandy marl and hard bluish marl containing small grains of glauconite and some flakes of mica, but this description presumably refers to a lower level in the succession.

5. Conclusions

The balance of the evidence suggests that the assemblages should be attributed to an horizon within the *Neostlingoceras carcitanense* Subzone of the Lower Cenomanian *Mantelliceras mantelli* Zone, probably towards the upper limit of the subzone. Lithostratigraphically, this horizon falls low in the Chalk Marl. The preservation of the fauna is of high quality, and further collecting would be advantageous.

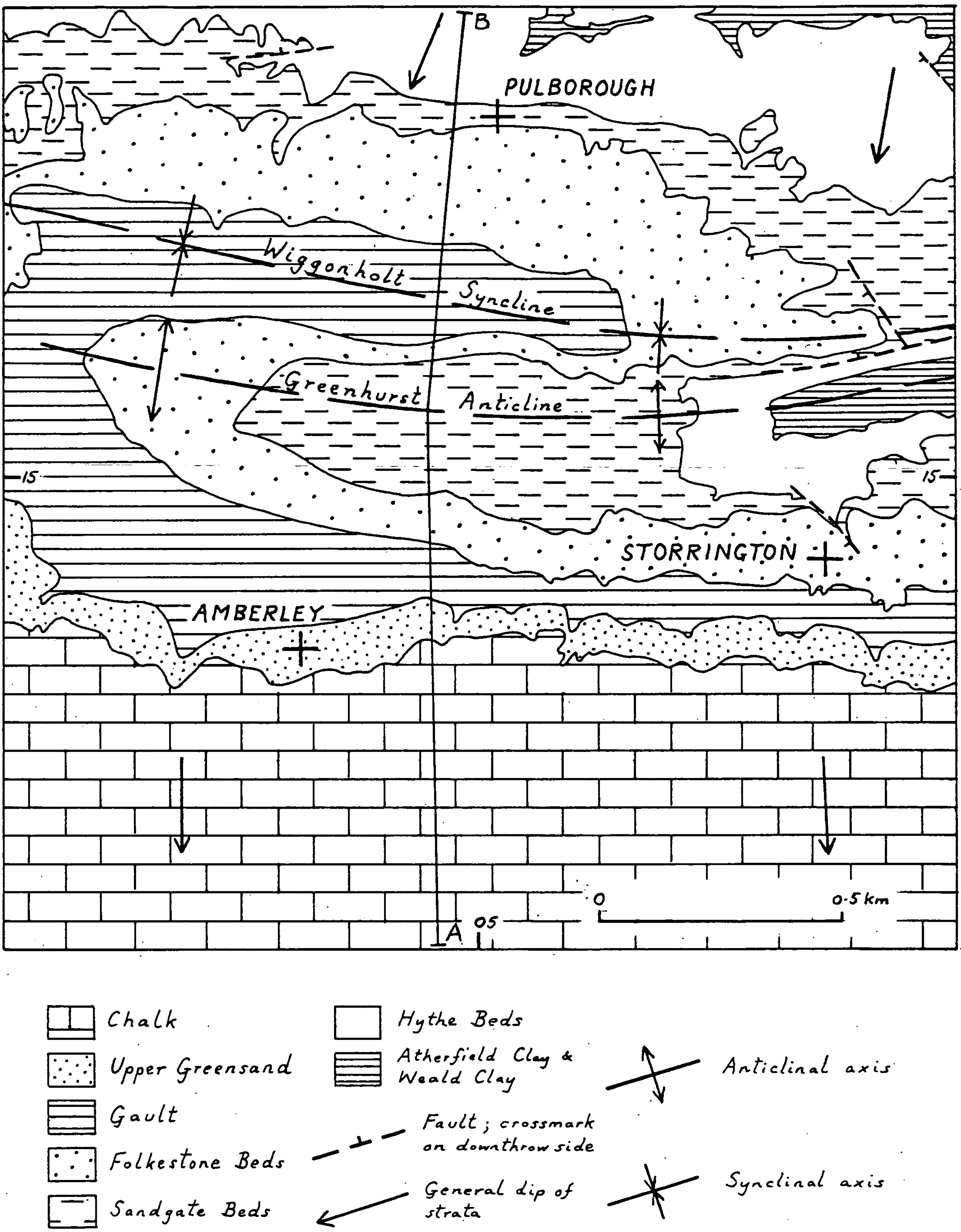


FIG. 1 MAP SHOWING OUTCROPS OF SOLID FORMATIONS AND STRUCTURE

(See Fig. 2 for cross-section along the line A-B)

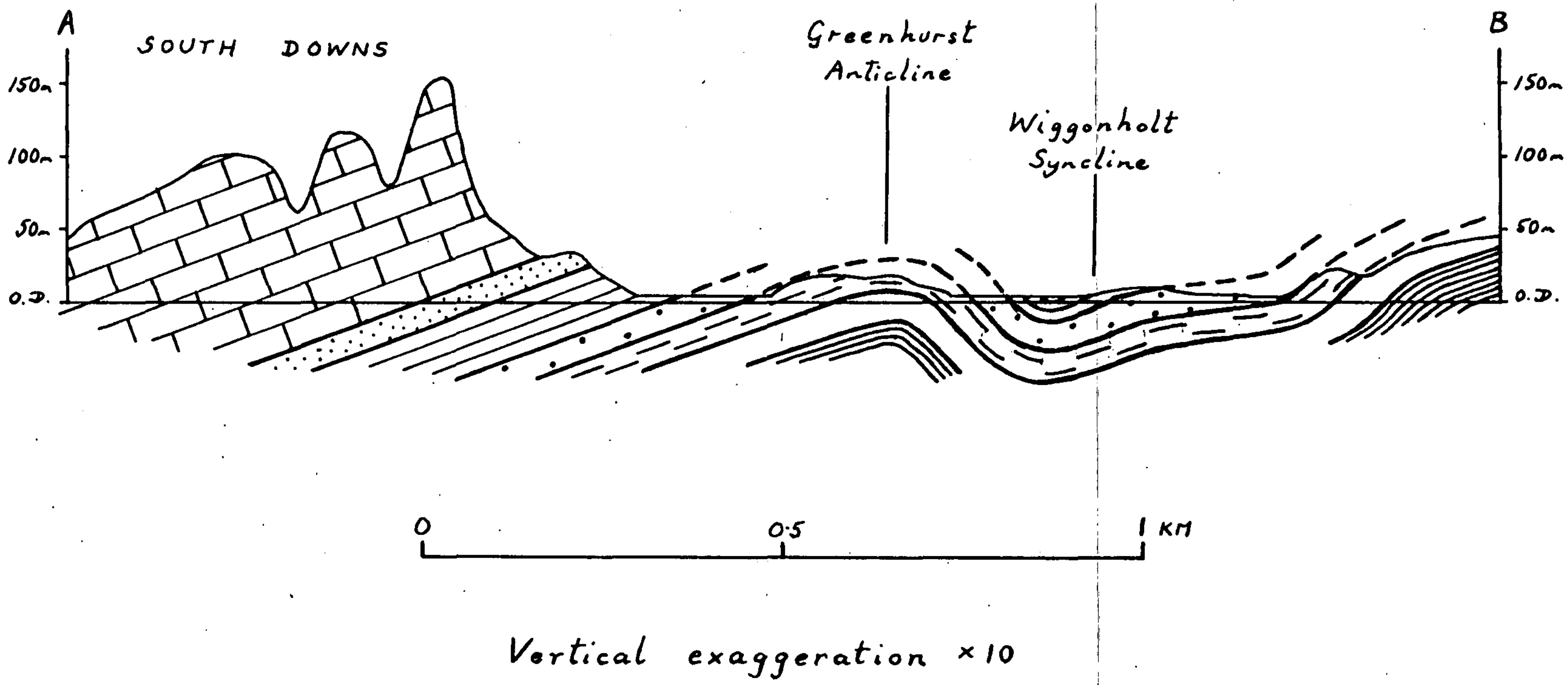
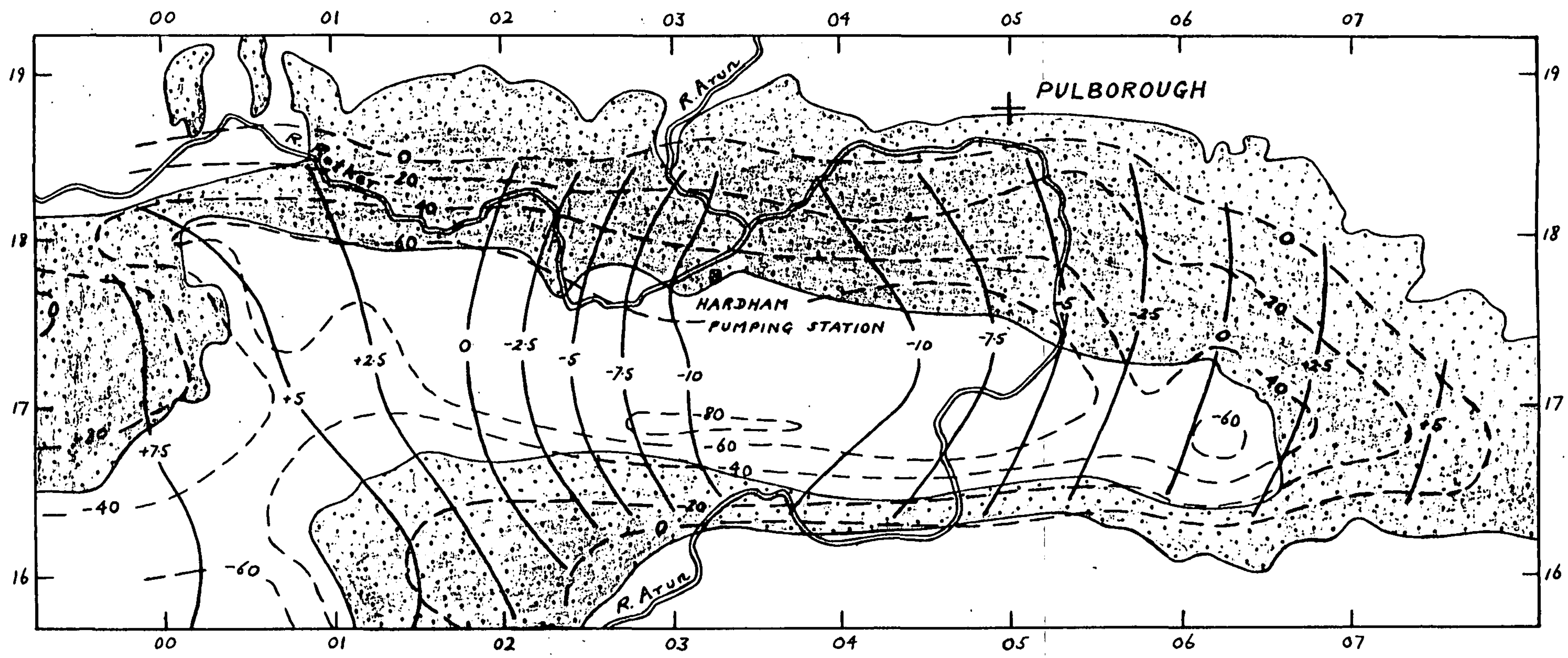


FIG. 2 Cross-section showing the structure of the area
(for line of section and key to ornament see Fig. 1)



Adapted from IGS/SWA Hydrogeological Map, 1978

Contours on the base of the Folkestone Beds in metres at (0) or below (-) O.D.

Contours on the Folkestone Beds water table (Sept. 1976) in metres above (+), at (0) or below (-) O.D.

Outcrop of Folkestone Beds

FIG. 3 Diagram showing the disposition of the Folkestone Beds aquifer in relation to the Wiggonholt Syncline and to the contours of the Folkestone Beds water table.