Natural Environment Research Council

British Geological Survey

Geology of Sheet SZ 19

(Hurn-Christchurch)

Part of 1:50 000 sheet 329 (Bournemouth)

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with contributions by

R.A.Monkhouse (Hydrogeology)

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INTRODUCTION

The original geological survey of the area comprising sheet SZ 19 was made by H W Bristow and J Trimmer at the one-inch to one-mile scale (1:63 360) as parts of Old Series Geological Sheets 15 and 16 published in 1856 and 1855 respectively. The drift deposits were not represented on these maps. Clement Reid resurveyed the area on the six-inch to one-mile scale (1:10560) in 1893, and his results were incorporated in New Series One-Inch Geological Sheet 329 (Bournemouth), published in 1895 in both Solid and Drift editions, and in the accompanying memoir (Reid, 1898). A second edition of this memoir was produced by H J O White, and was published in 1917. White re-examined much of the ground, but the published maps remained unaltered.

In 1983 the Institute of Geological Sciences (now British Geological Survey) was commissioned by the Department of the Environment (contract PECD7/1/0103-149/82) to provide new 1:10 000 geological maps of the Poole-Bournemouth area. This contract comprises the survey of ten 1:10 000 sheets, and parts of four others, (Figure 1) over three years, to form a basis for the planning of urban and industrial development, and the safeguarding of mineral and water resources. During 1983, in the first phase of the contract, the four constituent quadrants of

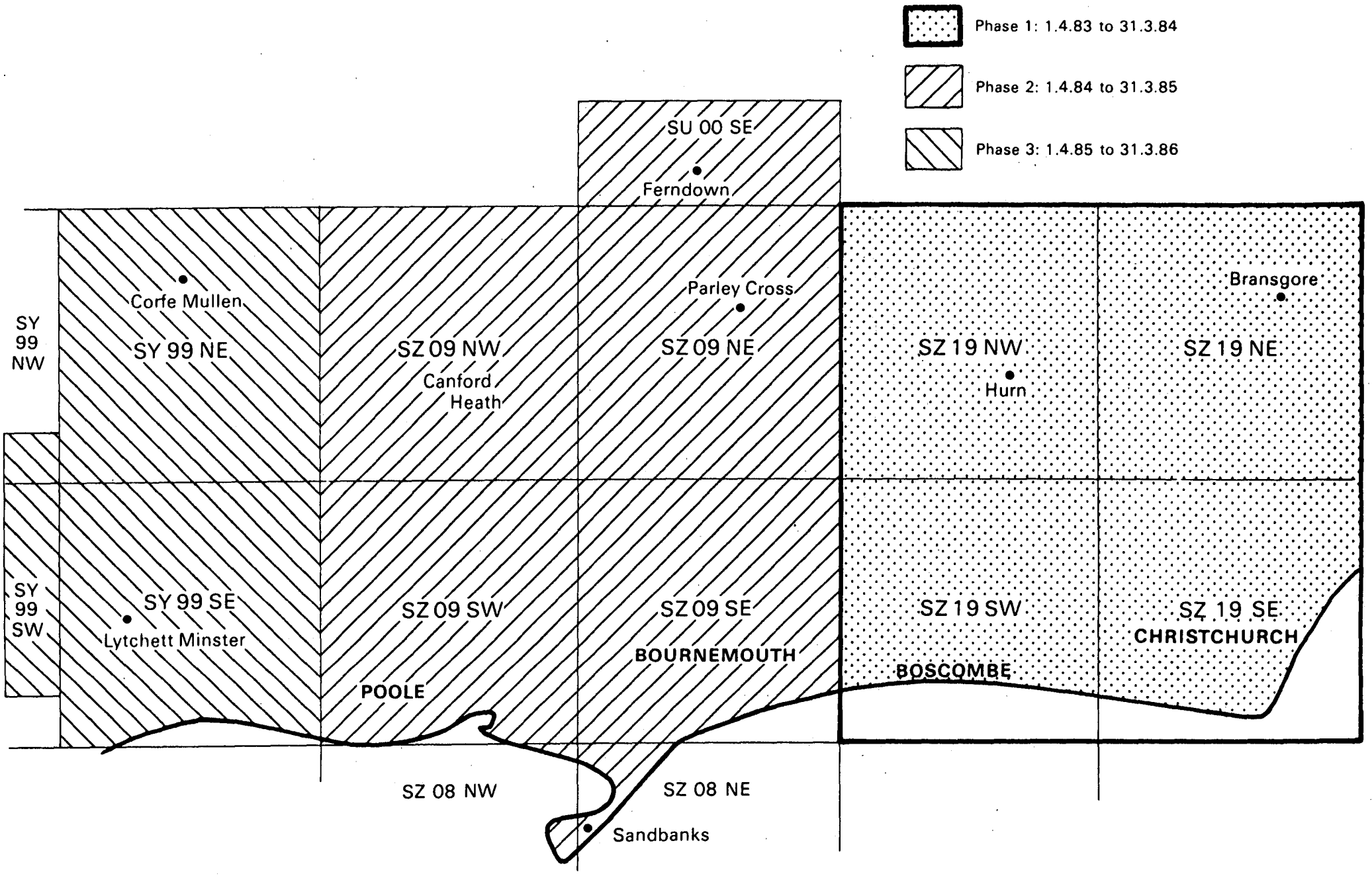


Fig. 1 Index map showing the area covered by the Poole-Bournemouth project and this Report.

Sheet SZ 19 were mapped as follows, under the direction of R W Gallois, District Geologist:

SZ 19 NW	B J Williams
SZ 19 NE	E C Freshney
SZ 19 SW	E C Freshney
SZ 19 SE	C R Bristow

The authors thank the Bournemouth and Christchurch Borough Councils in Dorset County Council and various consulting firms and their staff for their cooperation in obtaining borehole and other subsurface information for the area. Thanks are also due to Dr. R. A. Edwards for Fig.7, and to numerous landowners for access to their ground both for mapping and test drilling.

The area of sheet SZ 19 is dominated by the valley of the River Avon, which flows southwards down the middle of the area to the sea at Christchurch, where it is joined by the River Stour flowing from near the centre of the western margin. In turn, the Stour is joined by the southward-flowing Moors River south of Hurn. Most of the southern two quadrants are occupied by the urban areas of Bournemouth and Christchurch, and much of the north-western part by Hurn (Bournemouth) Airport. The north-eastern part of the area, east of the Avon, is more rural with a network of small villages set in mixed arable and pasture farmland.

Most of the area is underlain by rocks of the Palaeogene Bournemouth Formation, including the high ridge between the Moors River and the River Avon wherein, at St Catherine's Hill, the summit reaches 50m above Ordnance Datum (AOD). East of the Avon, stratigraphically higher Palaeogene beds crop out.There, the Barton Group and Headon Formation form the highest ground in the

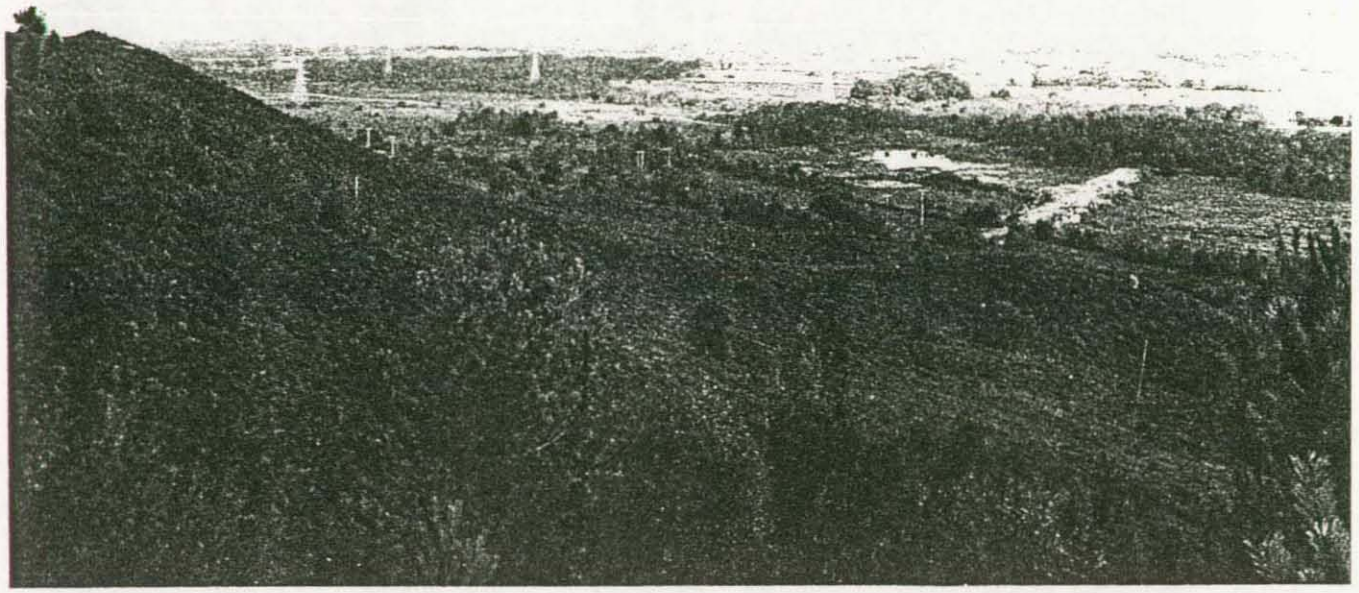


PLATE 1 View north-eastwards from St Catherine's Hill across the Avon Valley. Bournemouth Formation sands underlie slopes in foreground: River Terraces and Alluvium of the Avon occupy the middle ground; and Barton Group clays and sand, largely drift covered, crop out in the distant ground

district (75m AOD) in the north-eastern corner on the edge of the New Forest. About 85% of the sheet area bears a covering of drift deposits. These are chiefly River Terrace Deposits, consisting of sand and gravel, of economic importance. The floodplains of the rivers are floored by Alluvium forming rich pasture lands.

The geological succession present in the district is shown below in Table 1. Estimated thicknesses are given in metres, where known. The lower part of the Branksome Sand and the underlying beds have only been proved in boreholes in the present district. Abbreviated logs of selected boreholes are given on the map.

Table 1 Geological succession in the Hurn-Christchurch district

DRIFT DEPOSITS

Quarternary	Blown Sand
	Older Blown Sand
	Peat
	Alluvium
	River Terrace Deposits, Sands and Gravels
	River Terrace Deposits, Loam
	Marine Beach Deposits
	Estuarine Alluvium
	Storm Gravel Beach Deposits
	Head

SOLID FORMATIONS

SYSTEM	GROUP	FORMATION	MEMBER	THICKNESS
		Headon Formation		16
	Barton Group	Becton Sand		7
		Chama Sand		5
		Barton Clay		60
			Warren Hill Sand	0-10
		Bournemouth Formation		
			Boscombe Sand	c20
Palaeogene			Branksome Sand	60
		London Clay		99-108
			Christchurch Member	40-60
		Reading Beds		30
Cretaceous		Upper Chalk		30 proved

KNAPP MILL BOREHOLE
CHRISTCHURCH

|1544 9380|
SZ 19 SE / 9

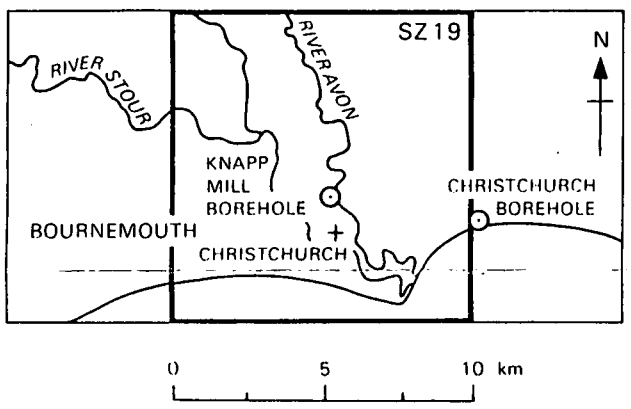
CHRISTCHURCH
BOREHOLE

|2002 9301|
SZ 29 SW / 12

KEY

- Sand
- Sand to very sandy clay
- Clay with sand and silt laminae
- Clay, undifferentiated
- Chalk
- Lignite
- Claystone (clay ironstone)
- Flint pebble bed
- R R R Red staining

Vertical Scale
0
10
20
30m



BOSCOMBE SAND

BRANKSOME SAND

CHRISTCHURCH SAND

BOURNEMOUTH FORMATION

LONDON CLAY

READING BEDS

UPPER CHALK

20 40 60 80 100 120 140 160 180 200 220 240 260 280.72

20 40 60 80 100 120 140 160 180 200 220 240 318.55

Fig. 2 Comparison of the Tertiary sequences proved in the Knapp Mill and Christchurch boreholes.

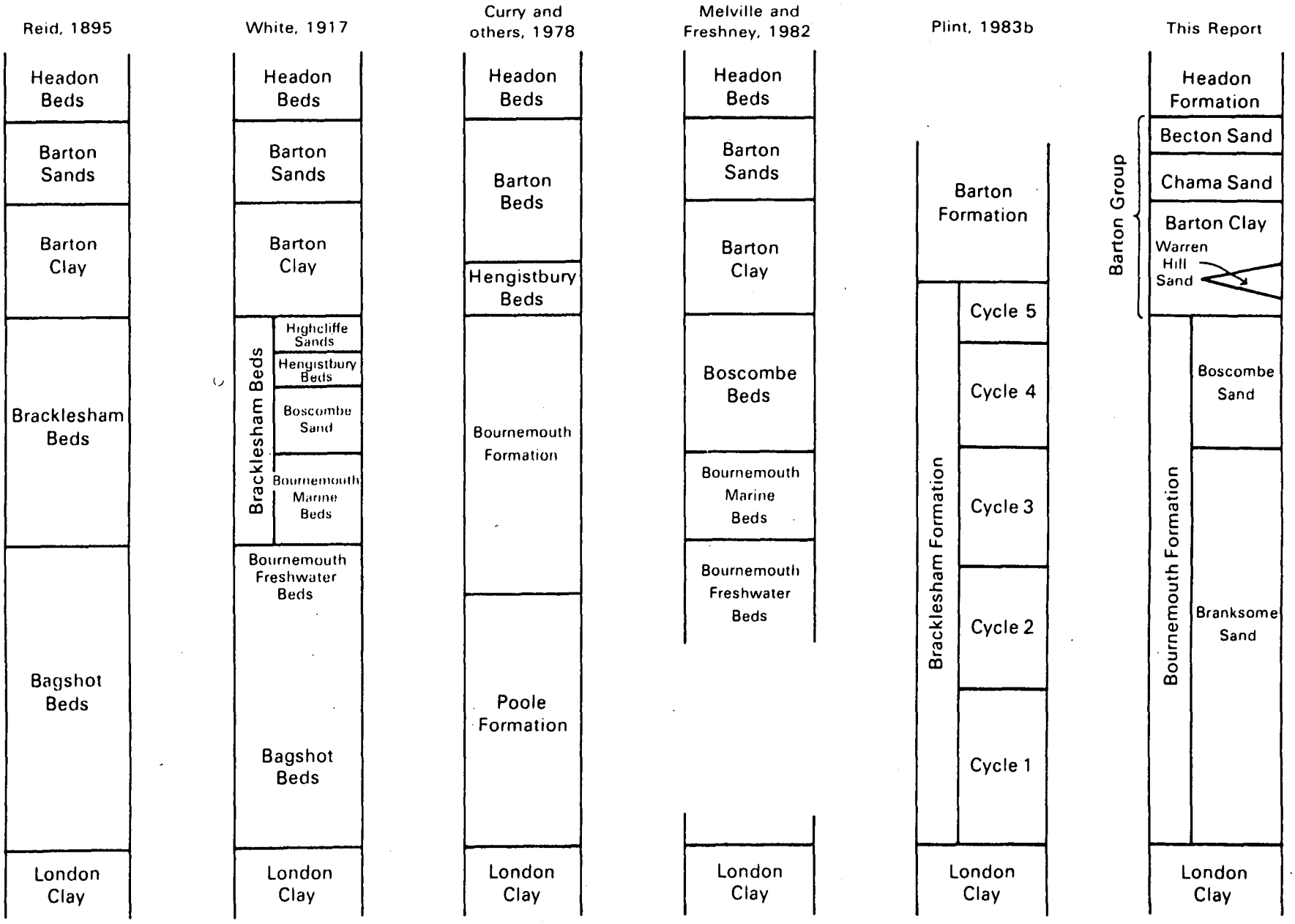


Fig. 3 Selected stages in the evolution of the nomenclature of the Palaeogene rocks of the district.

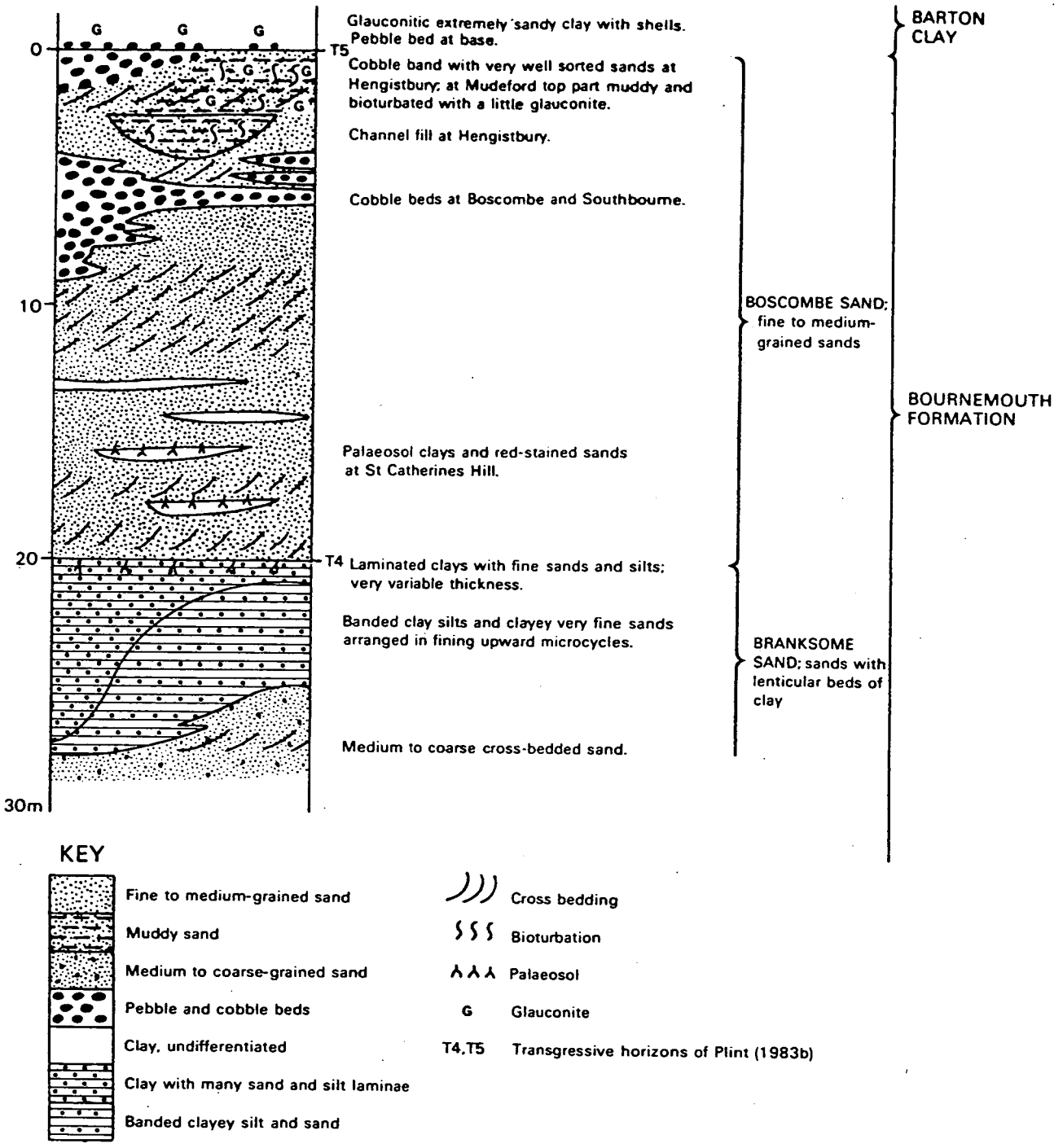


Fig. 4 Generalised stratigraphy of the Bournemouth Formation within SZ 19.

2. PALAEOGENE

The Palaeogene exposed in the present area ranges from the upper part of the Bournemouth Formation to the Headon Formation. At depth the Reading Beds, London Clay and the lower part of the Bournemouth Formation were penetrated in the Knapp Mill and Christchurch boreholes (Fig.2). These formations crop out in the area to be mapped in 1984/85 programme and will be described in a later report.

Selected stages in the evolution of the nomenclature of the Palaeogene rocks of the district are shown in Fig. 3 together with the terminology used in this report. All the solid formations that crop out are Eocene in age.

BOURNEMOUTH FORMATION

The Bournemouth Formation at outcrop in the present district consists mainly of fine- to medium-grained sands and, locally, coarse-grained sands with lenticular beds of laminated brown to greyish brown clay. Fine-grained sands with clay and clayey sand bands, remobilised clayey sands and palaeosols also occur.The generalised stratigraphy of the Bournemouth Formation is shown in Fig.4.

The Palaeogene comprises the Palaeocene, Eocene and Oligocene; it is used here because of the difficulty of defining the Eocene-Oligocene boundary in the Hampshire Basin.

The terms Poole Formation and Bournemouth Formation were introduced by Curry and others (1978) for the predominantly arenaceous strata that crop out in the area to the south and north of Poole Harbour respectively. They embrace the Bagshot Beds and Bracklesham Beds of One Inch Geological Sheet 329 (Bournemouth), first published in 1895 and are broadly equivalent to Plint's (1983b) Bracklesham Formation (Fig.3).

The boundary between the Poole and Bournemouth formations was not defined by Curry and others (1978) but appears to have been taken at a break (Poole Harbour) in the exposed sequences. The present authors are of the opinion that both formations (here referred to as the Bournemouth Formation) should be regarded as a single unit until such time that the type area has been geologically surveyed in detail.

The highest part of what is here termed the Bournemouth Formation has been called the Boscombe Sand since the time of Gardner (1879). The lower part has given rise to a number of names, some of which are synonyms and all of which are poorly defined. The new name Branksome Sand (after Branksome Chine) is here proposed for the lower part of the Bournemouth Sand. A detailed description of the type section (the cliffs between Sand banks and Southbourne) will appear in a later report (SZ18).

The base of the Bournemouth Formation does not crop out in the present district, but in the nearby continuously cored Christchurch Borehole [2022 9301] the formation can be divided into two lithological parts which correspond with the Branksome Sand and the Boscombe Sand. The junction between these members is

mappable in the cliffs in the present district at Southbourne, in inland areas such as St Catherine's Hill where there is adequate outcrop information, and in urban areas where there is sufficient borehole data.

The Bournemouth Formation crops out in the Boscombe [120 913], Southbourne [145 912] and Hengistbury [169 906] areas, where it is well exposed in the cliffs, in the area between St Catherine's Hill [145 955] and Hurn [130 970], and in a more limited outcrop, from North Ripley [166 998] in the north to the Hinton Admiral [200 948) area in the south. It also underlies most of the major gravel spreads of the Rivers Stour and Avon.

BRANKSOME SAND

The Branksome Sand at outcrop in the district consists mainly of carbonaceous, rhythmically banded, silty sands. Coarse- to medium-grained sands are seen low in the succession at the western end of the coastal sections at Southbourne, and have been encountered in boreholes throughout the district. Laminated brown silty clays occur at the top of the member. These clays although present over most of the area, are very variable in thickness and range from a few centimetres up to 20m; the thicker clays appear to occupy channels. A palaeosol is commonly developed at the top of the clays.

The junction of the Branksome Sand and London Clay does not crop out in the district; the base of the sand will probably be defined in a type section in the area south of Poole Harbour. In the Christchurch Borehole the base of the sand is taken at a

depth of 191m where an erosive contact occurs between a sequence of medium- to coarse-grained, cross-bedded, sands and laminated clays (Branksome Sand) and, micaceous, banded, clayey, very fine-grained, glauconitic, sands, silts and clays with some bioturbation (London Clay).

The sands of the Branksome Sand consist mainly of quartz, although flint grains are particularly common in the coarser-grained sands.The mean grain size (1) range is slightly coarser (0.90 = 530 μm)to 3.10=117μm)) than that of the Boscombe Sand,(see p. 15) although the average is similar at 2.10=133μm). The average sorting is poorer (0.50) and the average skewness is more positive (0.22).than the Boscombe Sand.

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(1)
The grain-size parameters used throughout this report are those defined by Folk and Ward (1957). These parameters are widely used by sedimentologists because they enable rapid comparisons to be made between different types of sand and gravels, but they have yet to find general acceptance with geotechnical engineers.

ϕ (phi unit) ....1/Log grain size in millimetres e.g. 2mm= -1ϕ; 16mm = -4ϕ; 0.25 mm = 2ϕ.

$$\text{Mean Size (Mz)} = \frac{\phi 16 + \phi 50 + \phi 84}{3}$$

where $\phi 16$ is the grain size (inϕ) at 16 wt% cumulative grain-size curve.

$$\text{Sorting (Inclusive Graphic Standard Deviation of Folk and Ward)} = \frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$$

The lower the sorting value, the better sorted the sample. Most sediments have values between 0.35 and 4.00.

Skewness (Inclusive Graphic Skewness of Folk and Ward) =

$$\frac{\phi 16+\phi 84-2\phi 50}{2(\phi 84-\phi 16)} + \frac{\phi 5+\phi 95-2\phi 50}{2(\phi 95-\phi 5)}$$

For a perfectly symmetrical grain-size distribution curve skewness = 0. Samples with a relative preponderance of finer grains have positive skewness values, those with a greater relative preponderancy of coarser grains have negative Skewness values. The absolute mathematical limits for skewness are -1.00 to +1.00, but few sediments lie outside the range -0.80 to + 0.80.

The carbonaceous clays and silts at the top of the member have yielded dinoflagellates of the Cyclonephelium intricatum Assemblage Zone(B-5) of Bujak and others (1980) and indicate correlation with the lower part of the Barton Clay of the eastern part of the Hampshire Basin. At Bournemouth, Gardner(1879) found marine bivalves and gastropods including Ostrea dorsata, Arca sp., Modiola sp., Tellina tenuistriata, Calyptaea trochiformis, Phorus agglutinans, Natica labellata, and Cerithium sp. in clays at the top of the Branksome Sand. This assemblage is, however, not diagnostic of any particular biostratigraphical level in the Tertiary.The bulk of the Branksome Sand was probably deposited contemporaneously with the Bracklesham Group of more easterly parts of the Hampshire Basin.

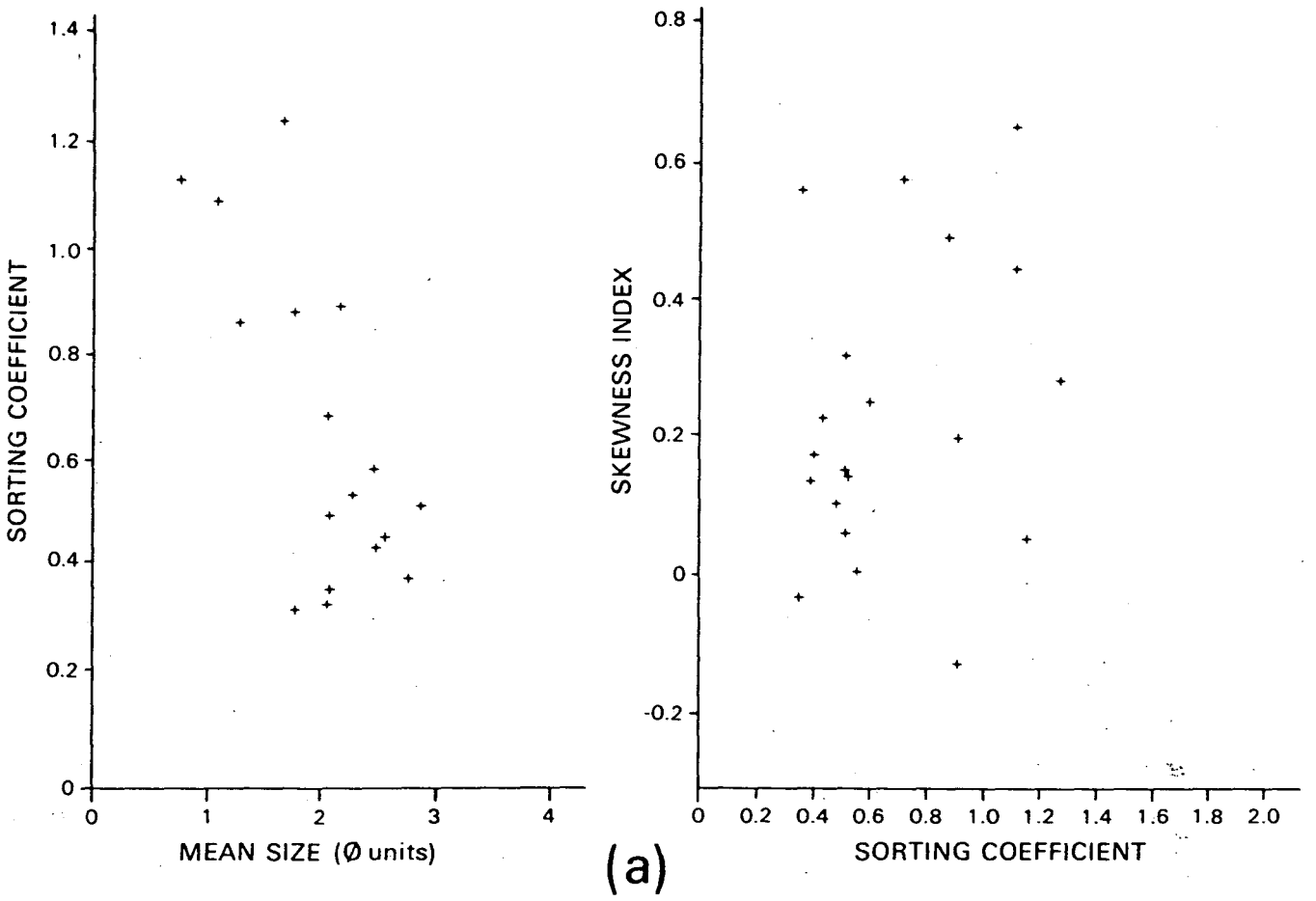
BOSCOMBE SAND

The Boscombe Sand mainly comprises well-sorted, fine- to medium-grained, sand with pebble and cobble beds near the top.It is commonly cross bedded. About the top 10m of the member in the Hengistbury Head and Mudeford areas are made up of muddy carbonaceous silty sand from which a shelly fauna was recorded by Chandler (1963). Thin pipe-clay-like seams are fairly common throughout the district; palaeosols, clays, and red-stained sands occur at St Catherine's Hill.

The base of the Boscombe Sand is taken at a sharp lithological change from laminated carbonaceous brown clays (Branksome Sand) to fine- to medium-grained sands. At localities where the highest bed of the Branksome Sand is a sand, the boundary is taken at an erosion surface, marked by contrasting sedimentary and grain-size features in the sands, that was regarded as a transgression surface by Plint(1983b).

The Boscombe Sand has extensive outcrops in the Boscombe, Southbourne and St Catherine's Hill areas, but is mostly covered by River Terrace Deposits.

The sands of the Boscombe Sand consist mainly of quartz grains, but at some levels flint grains are common. The Mean Grain Size varies between 1.00(500μm) and 3.50(88μm) with an average of 2.20(218μm). The sorting ranges between 0.180 and 1.70 with an average of 0.420 and the skewness between +0.70 and -0.50 with an average of +0.10. Some samples, notably those from the top of the Boscombe Sand at Hengistbury Head, have a sorting average of 0.30 and a skewness averaging of -0.40. Scatter plots



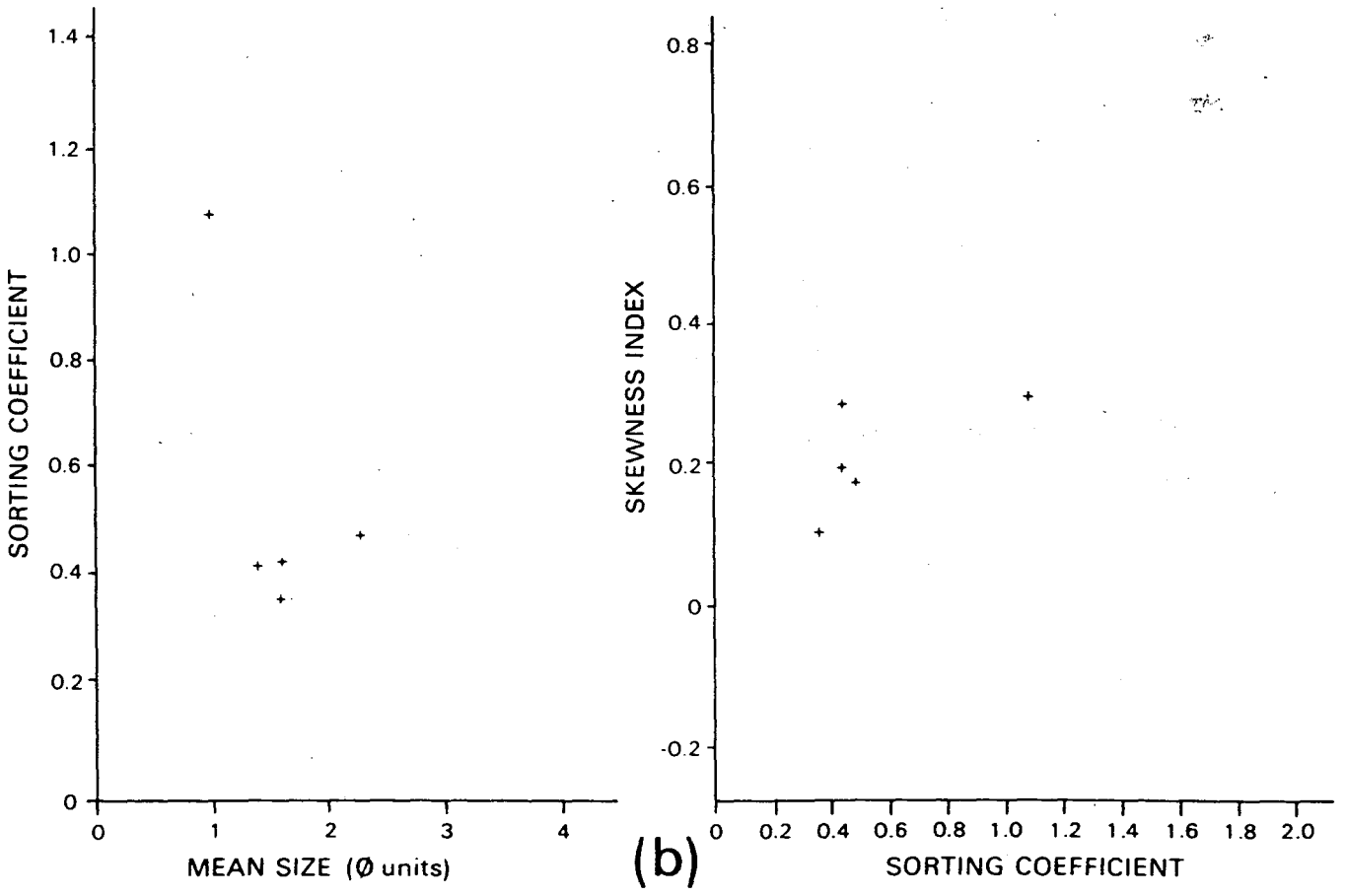


Fig. 5 Scatter plots of grain size characters for Bournemouth Formation Sands
(a) SZ 19 NW (b) SZ 19 NE

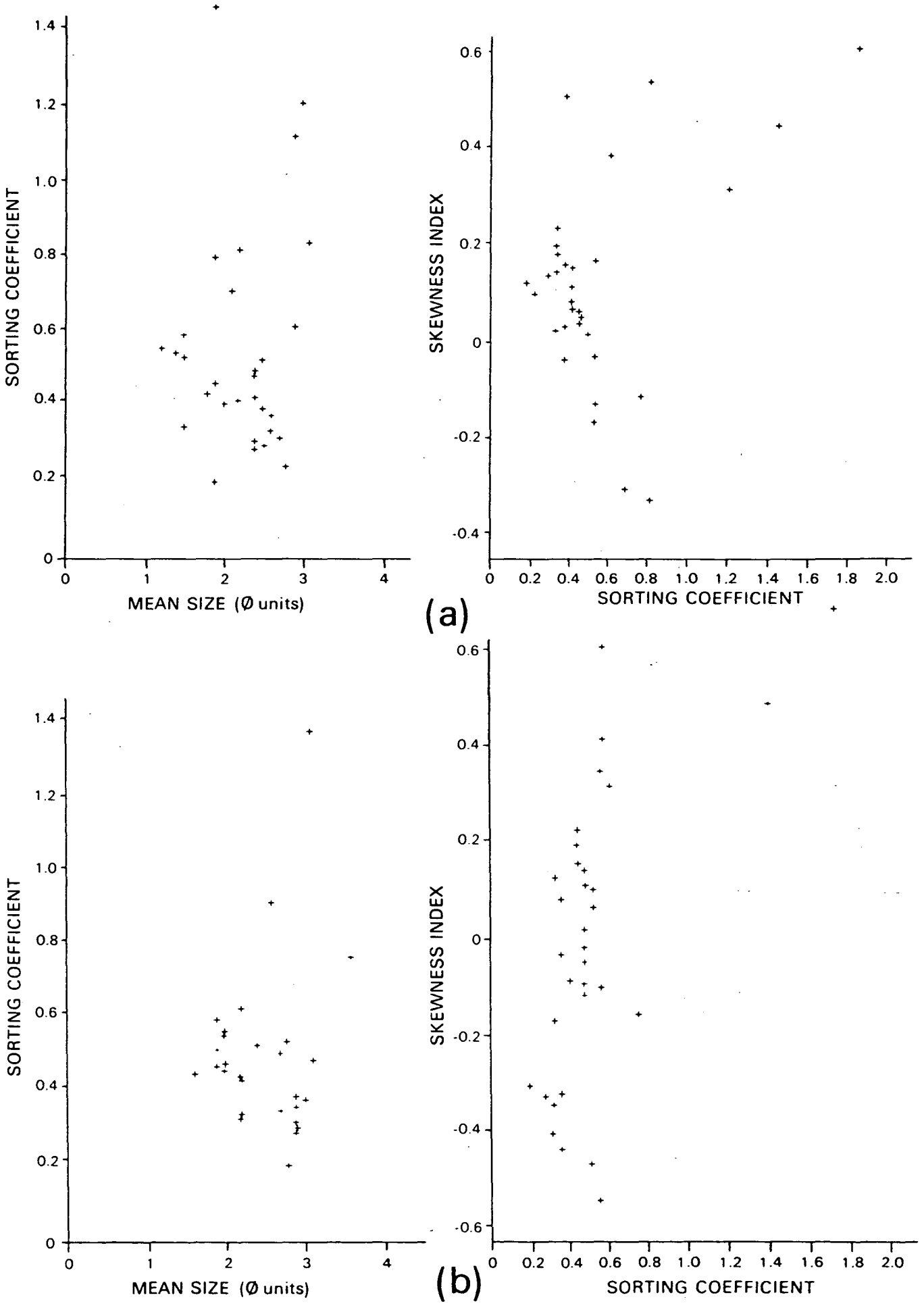


Fig. 6 Scatter plots of grain size characters for Bournemouth Formation Sands
(a) SZ 19 SW (b) SZ 19 SE

of mean size/sorting, and sorting/skewness for the four sheet quadrants are shown on Figs 5 and 6. The Boscombe Sand has yielded no body fossils. The topmost bed of the member at Hengistbury Head contains dinoflagellates indicative of the C. intricatum Assemblage Zone, as do the clays at the top of the Branksome Sand.

There is faunal and floral evidence from outside the present district to suggest that these higher beds of the Bournemouth Formation are contemporaneous with marine clays in the New Forest area (Huntingbridge Formation of Curry and others, 1978).

Conditions of deposition

The Bournemouth Formation in the present district was probably deposited in a marginal marine (?estuarine) and fluviatile environments. The Formation pass eastward in the New Forest into fully marine beds such as the Barton Clay and Bracklesham Group. Recently, detailed sedimentological studies by Plint, (1980; 1983a; b; c) suggest that the bulk of the Branksome Sand, at outcrop in the cliffs between Bournemouth Pier [089 906] and Canford Cliffs [058 892] was deposited as fluviatile point-bar sands in a series of fining-upward cycles. The highest, more carbonaceous, banded sands and clays he regarded as estuary channel deposits,and the markedly lenticular clays within them as channel plugs. Some of the channel-plug sediments were sufficiently raised above water level to have palaeosols developed on them. These channel-plug clays are particularly well developed around Christchurch Harbour [170 915] and Holdenhurst [132 953] (Fig.4) and, to a lesser extent, in the Queen's Park

[105 933] and King's Park [118 927) areas of Bournemouth. They appear to form a channel system trending between W-E and WNW-ESE.

The palaeosol commonly developed at the top of the Branksome Sand indicates a period of emergence. This was followed by a transgression which resulted in shore-face sands (the lower part of the Boscombe Sand) being deposited over the partly subaerial surface of the Branksome Sand (Plint, 1983b). The palaeosols and red-stained sands at St Catherine's Hill indicate a longer period or greater degree of local total emergence, and it is possible that some of the sands there are aeolian. The shore-face sands pass up into bidirectionally cross-bedded, and hence tidally influenced, sands that were probably deposited in channels within an estuary. These channel sands contain lenticular masses of flint cobbles that were probably washed into the channels from nearby beaches during storms.

At Hengistbury and Mudeford the uppermost part of the Boscombe Sand contains upward-coarsening, carbonaceous, silty, bioturbated sands, and remobilised muddy sands (slurry beds) containing clasts of bituminous sand. These deposits were regarded by Plint(1983b) as estuary mouth bar sands and estuary channel plugs respectively. At the western end of the Hengistbury Head, an impersistent layer, up to 1.25m thick, of well sorted fine-grained sand with cobble beds at the top and bottom occurs. These deposits probably represent a return to shoreface conditions, the cobbles having been derived from a storm beach.

Branksome Sand Details

The Branksome Sand is exposed only in a very limited area of the present district. It occurs mainly in the lower part of the cliffs between Bournemouth [100 910) and just east of Southbourne [155 910]. Sections at the western end are dominantly in fine-grained sand. A typical section [1086 9113) is as follows:

	Thickness (m)
Clay, olive-grey, homogeneous, with rootlets at the top passing down over 0.6m into a banded olive-grey clay and silty, very fine-grained, sand; the sand bands are arranged in thin(1cm) upward-coarsening units	1.3
Sand, very fine-grained, pale brown, with lignitic debris and dark sulphide stain	0.8
Sand, very fine-grained, olive-grey to brown, banded with clay layers	1.0 (seen)

A borehole [1015 9107] on top of the cliffs proved brown sand and rather clayey sand between a depth of 14.63 and 33.22m, overlying 4.97m of hard grey clay, which in turn rested on a hard, grey coarse-grained sand down to 41.5m.

A section [1105 9115] in banded ferruginous clay and silt at the top of the Branksome Sand occurs just west of Boscombe Pier:

	Thickness (m)
Interlaminated and interbanded clayey silt and very fine-grained sand with a few brown laminated clay layers; much fine-grained lignitic debris; some wedge bedding	more than 8.0
Sand, fine-grained, clayey, with disrupted streaks of clay, brown to orange	about 1.0
Clay, dark brown,lignitic, passing rapidly down into fine-grained brown sand showing rough banding with bands of slightly more clay-rich carbonaceous sand; burrows, including Ophiomorpha,in the lower part	over 1.5

Farther east, smaller exposures [1460 9112] of laminated dark brown clay and fine-grained sand occur at the top of the Branksome Sand. East of Southbourne, 4m of gravel were noted above dark grey clay at one point [1533 9099]. The 1m of laminated dark brown lignitic clay recorded by Hooker (1975) at the base of the Hengistbury section is thought to lie at the same horizon.

In the BGS Hengistbury No.3 auger hole [1805 9072] 0.9m of stiff dark brown clay with disseminated and small (up to 1cm) lumps of marcasite was proved between 17.5 and 18.6m below OD. A similar clay was proved between 9.5 and 14.6m below OD in the Stanpit No.1 [1715 9235], between 6.6 and 10.2m below OD in the Stanpit No.2 [1697 9212] and between 14.7 and at least 19.4m below OD (possibly with some interbedded sand) in the Stanpit No.3 [1700 9168] auger holes. A poor dinoflagellate flora was recovered from these clays during the present work. The flora includes species of Apectodinium indicative of an inner neritic, possibly estuarine environment of deposition.

Three metres of dark silty clay recorded in a borehole [1606 9170] near Wick between 12 and 15m below OD are also thought to be a clay within the Branksome Sand.

Gardner's (1879) reference to "dark sandy clay with ironstone nodules" seen in the bottom of The Run near Mudeford Ferry [c.1830 9155], and also farther north-east in the left bank of The Run, may be a clay at the top of the Branksome Sand. Gardner (1879), who recorded ironstone nodules "upon and about" the surface of the clay, thought that the nodules were the same

as those in the Barton Clay at Hengistbury (see p.43). Chandler (1963,pp.18-19), however, saw sections in The Run during 1933 and 1934 and stated that the ironstones were more like iron-cemented sands and not at all like the ironstone nodules at Hengistbury. Chandler obtained a limited flora from these beds.

Inland, exposures in the Branksome Sand are rare. The clay at the top of the Branksome Sand has in the past been extensively worked for brick clay near King's Park [around 1166 9270] and Queen's Park [around 1060 9328 and 1020 9340]. At Queen's Park the following section [1064 9323] was recorded by Clement Reid in 1893: 3.1m of laminated white clay, overlying 2.4m of black loam, which in turn rested on 3.7m of black loam and lignite. The same clay was worked in another small brick-pit close by [1052 9198].A borehole [1045 9200] near this latter pit proved 1.85m of stiff dark brown silty clay, laminated with silt and sand partings, overlying 4.6m of hard brown, laminated, silty clay with partings and laminations of black and yellow sand. An exposure [1104 9317] in the sands below the top clay unit occurs in a small gully on the Queen's Park Golf Course. There over 2m of grey-brown, somewhat carbonaceous, medium- to coarse-grained sand with streaks of lignitic material can be seen.

East of Boscombe Pier the following section [1210 9126] in a channel plug is exposed: 0.1m of brown clay passes down into more than 2.5m of brown lignitic sand with a few thin brown clay layers. The channel plug is about 25m wide. Another section nearby [1250 9128] showed:

	Thickness (m)
Sand, very fine-grained, silt and clay roughly banded, brown to buff with impersistent clay layers, some parts bioturbated	1.3
Sand, fine-grained, lignitic, brown	1.0
Sand, very fine-grained, silty, yellow with ferruginous cemented harder bands and some cream clay bands	over 0.5

A borehole [1128 9111] penetrated a section below that seen on the cliffs. The borehole entered the Branksome Sand at 2.87m below OD and proved the following succession:

	Thickness (m)
Branksome Sand	
Clay, firm to stiff becoming stiff, fissured, dark grey silty	2.9
Clay, silty, dark grey, laminated with medium- to coarse-grained sand and partings of fine-grained sand and lignite	2.8
Sand, medium-grained, becoming coarse-grained with depth, dense, grey; scattered thin very silty clay lenses	1.3 seen

A section [1348 9127) to the east was as follows:

	Thickness (m)
Branksome Sand	
Fine clayey sand with common laminae of brown clay	over3.0
Sand, fine-grained, yellowish orange with some lateritic seams and some bands of ferruginous sandstone particularly near the base	7.0
Sand, fine-grained, clayey, brown to orange with disrupted clay laminae	1.0
Clay, dark brown, lignitic passing down into fine-grained, brown sand showing rough banding with bands of slightly more clay-rich carbonaceous sand. Possible Ophiomorpha burrowing in lower part	over1.5

A tunnel between Littledown [1190 9397] in the north and Boscombe [1220 9177] in the south, cut the topmost clay of the Branksome Sand in several places [for example 1190 9218 and 1191 9392]. Adjacent to both the above occurrences of clay, and probably stratigraphically below them, there is a sequence of fine-grained, silty sand, banded with clayey silty sand.

Christchurch town is probably underlain by the Branksome Sand. Trial boreholes in the central redevelopment area [around 158 928] have proved a variable thickness of River Terrace Deposits above dominantly fine-grained, moderately well sorted(Fig.15), grey to brown, dense sand. A maximum thickness of 8.5m has been proved.

In the absence of adequately logged boreholes, it is not everywhere possible to differentiate with any certainty the Branksome Sand from the Boscombe Sand under the deposits of the River Stour. Some boreholes, however, proved laminated clays which may be part of the Branksome Sand.

One borehole [1071 9499] encountered a stiff, greyish brown, laminated, silty clay and fine- to medium-grained sand immediately beneath River Terrace Deposits. Laminated clays and fine-grained sands at the top of the Branksome Sand are exposed in the side of a track [1461 9473] on St Catherine's Hill, and were proved in a piston-sampler hole [1460 9473] nearby.

A number of boreholes penetrated laminated silty clay, with lignitic fine-grained sand, at the top of the Branksome Sand beneath the Terrace Deposits of the River Avon. One such hole [1529 9657] encountered 1.6m of silty, brownish grey, laminated clay, with fine- to coarse-grained sand partings, resting on clayey fine- to medium-grained, dark brownish grey, clayey sand. Another hole [1548 9849] farther north proved 1.8m of silty laminated clay, resting on more than 3m of fine- to medium-grained, silty lignitic dark greyish brown clay with some laminated clay layers.

In the Hurn area the only outcrop of the Branksome Sand, apart from the Hurn Forest-St Catherine's Hill ridge, is a narrow strip [111 972] around Merritown on the north bank of the River Stour between the Alluvium and River Terrace Deposits. Several boreholes, however, in the drift-covered areas penetrated significant amounts of Branksome Sand (Clarke, 1981). One such borehole [1083 9947] proved 4.1m of medium-grained sand with some fine-grained subangular to subrounded quartz and a minor proportion of flint; small subangular flint pebbles were present between 6.6 and 8.6m depth; thin silty clay laminae occured at several levels. Another borehole [1024 9731] encountered 3m of greyish brown, lignitic, medium-grained quartz sand, with some fine, subrounded to well rounded grains, beneath 2.7m of River Terrace Deposits. A third borehole [1183 9723] proved 1.1m of sandy silty clay resting on 1.5m of silty laminated greyish brown clay.

The major solid outcrop in the Hurn area extends from Hurn Forest [109 999], south-south-eastwards to St Catherine's Hill [145 955]. The tracks and paths of Hurn Forest are bordered by shallow ditches and in these, sands and clays are commonly exposed beneath a thin skin of flinty loam and gravel. Some 2.15m of fine-grained, pale brown, sand, with thin mauve clayey mudstone lenses up to 1cm thick, were seen in a temporary exposure [1213 9987] 700m W of Longfield. An intermittent stream near this exposure has revealed the following section [1220 9962]:

	Thickness (m)
Gravel, flinty	0.80
Boscombe Sand	
Sand, fine-grained, pale brown, locally cross-bedded with thin ferruginous layers and two thin seams of small subangular flints at 0.20 and 0.25m below the top	1.75
Clay, greyish brown, silty and sandy, with coarse-grained sandy bands up to 1cm thick	0.20
Clay, black, carbonaceous, plastic	0.05
Sand, fine-grained, brown, interlaminated with grey silty sand sandy clay	1.10 seen

In the woodlands at Avon Common, exposures [around 130 986] of white, fine-grained, sand are common east of Matcham's Lane.

Boscombe Sand Details

The Boscombe Sand is well exposed in many sections along the cliffs between Boscombe Pier [112 912] and Southbourne [153 910]. North-east of the Pier a road-side section [1133 9125], exposes 4.5m of buff to grey, fine-grained sand with many 2 to 5-mm thick clay-rich layers. Exposures high on the cliffs [around 120 913] show yellow, fine-grained sand with a well developed flint cobble

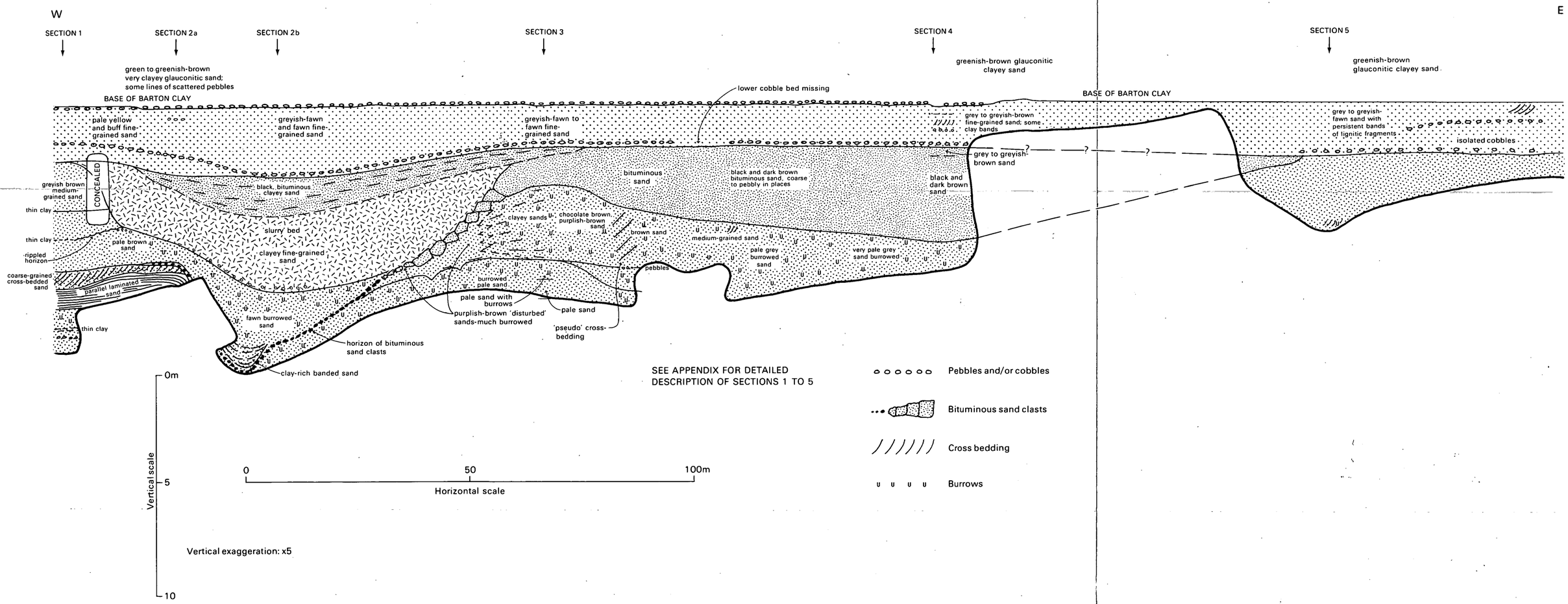


Fig.7 Cross section of the Boscombe Sand at Hengistbury Head showing lateral facies variations

bed, the cobbles being up to 10cm diameter. The cobble beds can also be seen high on the cliffs farther east [around 1319 9129], where 0.5 to 1m of cobble gravel overlies yellowish orange, cross-bedded, fine-grained sand over 1.5m thick. Another section [1370 9127] 50m to the E exposes:

	Thickness (m)
Boscombe Sand	
Cobble bed, flints	over 1.0
Sand, fine-grained, yellow to orange, with some ferruginous bands	1.5
Sand, fine- to very fine-grained, well sorted, with some thin ferruginous bands and some thin clay layers	over 3.0

Thin pebble beds are seen farther east in a car park on the cliff top [1467 9115]. The pebbles, which are bleached and very well rounded, occur in a matrix of fine-grained sand; very clayey fine-grained sand overlies the pebble bed.

Good exposures of the Boscombe Sand occur in the western part of Hengistbury Head [178 904] (Fig.7, and sections 1 to 7 in Appendix) and the western part of Friars Cliff, Highcliff [197 928].

White (1917,p.37), using Gardner's (1879) observations, constructed a vertical succession for the strata near Mudeford, and estimated that some 17m of sand intervened between the base of the Barton Clay and Gardner's "dark sandy clay" (ie.the top of the Branksome Sand). In the Christchurch Borehole [2002 9301] some 18m of sand were assigned to this same interval.

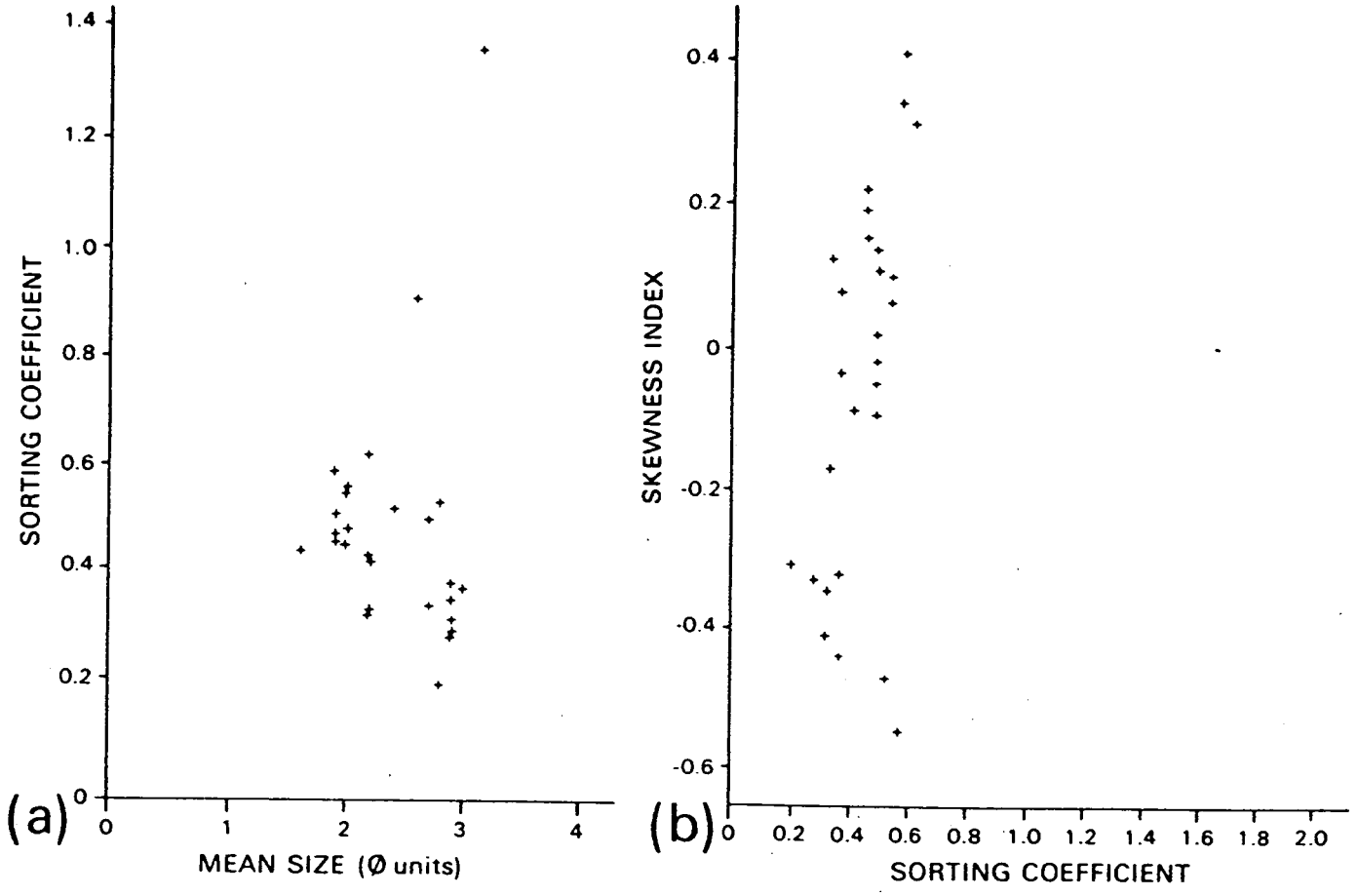


Fig. 8 Scatter plots of grain size characters of the Boscombe Sand at Hengistbury Head.
(a) Mean size / Sorting (b) Sorting / Skewness

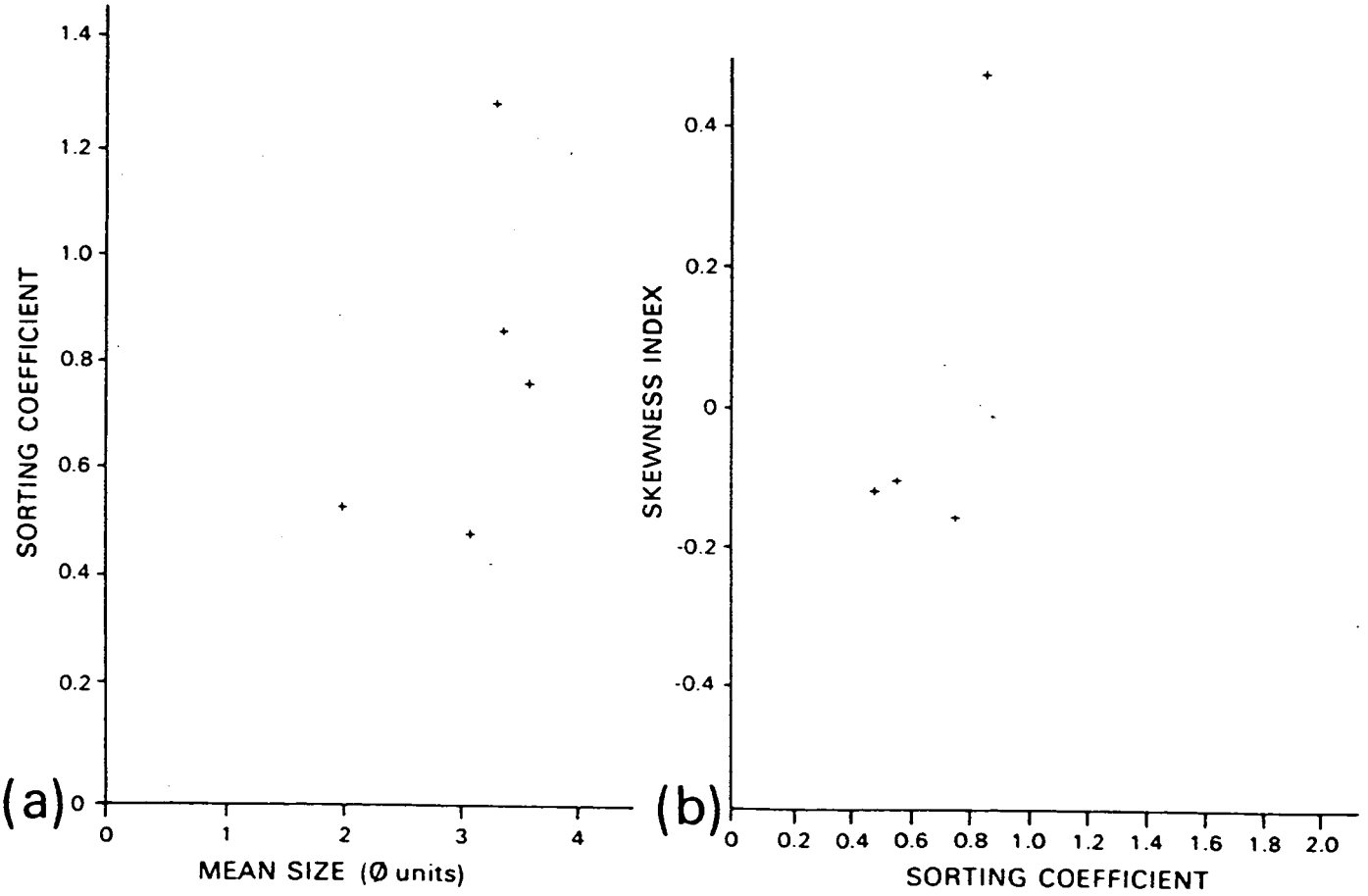


Fig. 9 Scatter plots of grain size characters of the Boscombe Sand from Friar's Cliff, Mudeford.
(a) Mean size / Sorting (b) Sorting / Skewness

The Boscombe Sand at Hengistbury consists dominantly of buff, brown or greyish brown, fine- to medium-grained, laminated, or locally cross-bedded, sand; burrowing is common. Stringers of pebbles occur in the lowest strata exposed; thicker concentrations of pebbles and cobbles occur at the top of the sand and these persist laterally for at least 350m in the cliff sections.

Towards the top of the Boscombe Sand at Hengistbury there is a bituminous-stained sand, up to 2.5m thick (Fig.7). At the western end of the section this sand is fragmented and the broken fragments form the base of a channel infilled with muddy sand. The origin of this bituminous bed and its subsequent disruption is described in detail by Plint (1983a).

The sands occupying the channel, and also others outside the channel below the lowest cobble bed, are well sorted, dominantly positively skewed and fine-grained. In contrast, the sands between the cobble beds in sections 1 to 4 are very well sorted, negatively skewed and very fine-grained (Figs 8 and 9).

At Friars Cliff [197 928], up to 11m of fine-, medium- and coarse-grained, buff and brown sand occur (see Figs.9a and b for grain-size analyses). A typical section [1980 9287] comprises:

	Thickness (m)
River Terrace Deposits	
Gravel, sandy	0.70
Clay, very sandy, fine-grained, glauconitic	1.50
Pebble bed of well rounded black flints within a glauconitic sandy clay	0.10
Bournemouth Formation (Boscombe Sand)	
Sand, fine-grained, structureless, buff	1.40
Sand, fine-grained, thinly bedded, buff	8.00
Sand, clayey, carbonaceous, dark greyish brown	0.40

Pebble bed with buff, soft, patinated flints	0.02
Sand, fine-grained, buff	0.30

The distinctive carbonaceous sand thins eastwards to about 0.2m some 60m E of the above section; a further 60m E this bed has descended to beach level and is not seen beyond this point [1992 9290]. The structureless sand at the top of the Boscombe Sand appears to have lost its original depositional features through quicksand action. Some 60m to the E [1986 9288] the uppermost bed of the Boscombe Sand consists of 8m of fine-grained, buff sand with ball-and-pillow structures. Most of the balls are between 0.5 and 1m, but some are up to 4m in diameter. Large-scale dewatering structures can be seen coming up through 4m of beds in this vicinity. Plint (1983b, fig.9) described three upward-coarsening, mouth-bar sequences, each about five to six metres thick, in this area. Each unit consists of an upward gradation from intensely bioturbated dark brown, sandy and silty clay, rich in plant debris, through silty sand into fine-grained, clean, faintly horizontally-laminated sand. This last is overlain by cross-bedded, fine- to medium-grained sand containing layers of mud pellets.

Chandler (1963, p.18) obtained more than fifty species of plant, together with the brackish or marine bivalve ?Meretrix, and the foraminifer Nummulites sp. from the Boscombe Sand at Friars Cliff. Burton (in Chandler, 1963) recorded unspecified molluscs from the same beds.

Inland exposures of the Boscombe Sand are rare. In the grounds of the caravan park [1952 9363] at Highcliffe, some 0.5m of fine-grained, buff and yellow sand could be seen beneath gravel.

Exposures occur locally on some of the steep north-easterly facing slopes in the Charminster area; for example fine-grained white sands are exposed [1047 9409] in a bank besides a path. The following boreholes and test pits all penetrate typical Boscombe Sand in the urban area of Bournemouth. A borehole [1022 9446] penetrated around 4m of compact, light grey, medium-grained, sand resting on about 2m of compact, grey, medium-grained, sand with bands of sandstone. Another borehole [1102 9373] penetrated, below 1.7m of drift, 2.4m of yellow sand, which rested on grey silty laminated clay at the top of the Branksome Sand. A test pit [1183 9337] exposed, below 1.2m of gravel and gravelly sand, 1.7m of yellow and white, fine-grained, sand containing bands of clay. A third borehole [1263 9277] proved the following sequence beneath gravel:

	Depth (m)
Sand, yellow, brown and green	0.50
Sand, silty, grey mottled, yellow	0.60
Sand, grey and yellow mottled with occasional silty bands	1.80

A fourth borehole [1280 9245] showed the following section beneath Made Ground:

	Depth (m)
Sand, fine-grained, light brown	2.13
Sand, fine-grained, light brown, dense	4.13
Sand, fine-grained, light brown, dense with clay bands	over5.83

At Southbourne several boreholes proved Boscombe Sand. One [1400 9173] showed, beneath gravel, 2.13m of yellow sand typical of the Boscombe Sand, resting on light grey sand with clay layers (Branksome Sand.)

A disused pit [1465 9494] on St Catherine's Hill shows the following section in Boscombe Sand:

	Thickness (m)
Sand, medium-grained, brown with ferruginous cement at top	0.2
Clay, grey, passing down into clayey, very fine-grained, sand; probable palaeosol	1.0
Sand, medium-grained, brown to yellow, well laminated at the top; some cross-bedding; coarse-grained sand layers in the lower 1.5m; erosional base	4.0
Sand, fine- to medium-grained, yellow to orange; irregular silty clay areas; laminated silt at top	over 1.5

In the Bransgore area, between North Ripley [170 000] and Hinton Admiral [200 950], the outcrop of the Boscombe Sand is almost completely obscured by River Terrace Deposits, but several boreholes penetrate the member. The lithology of carbonaceous silty and, locally, clayey sands is similar to that of the Boscombe Sand of the coastal exposures. A borehole [1662 9931] at North Ripley proved, beneath 6.6m of River Terrace Deposits, 2.6m of clayey, silty, lignitic, fine- to medium-grained sand. Another borehole [1745 9664] penetrated over 3m of clayey, silty, lignitic, fine- to medium-grained sand under 6.9m of River Terrace Deposits.

A section in a stream bank [1827 9727] at Bransgore, showed 0.7m of yellowish orange and brown, extremely sandy, clay and clayey sand of the Barton Clay, overlying 0.05m of well rounded flint pebbles, which in turn overlie 1.00m of orange-brown, medium-grained sand. The well rounded pebbles are considered as the transgressive basal bed of the Barton Clay. A disused gravel pit [1830 9702] at Bransgore exposed over 2m of ferruginous orange-brown, medium-grained, sand underlying River Terrace Deposits. An auger hole [1967 9517], 1.4km SE of the pit, penetrated the base of the Barton Clay at a depth of about 8m and entered brown sand, and fine-grained sandy clay of the Boscombe Sand which continued to a depth of 24 metres.

Farther south, greyish brown, clayey, medium-grained, sand was augered in a ditch [1930 9418]. Continuing southwards, fine-grained, orange and grey sand was augered in a bank [1951 9387]. In the railway cutting [1933 9466], fine-grained, orange and

buff, slightly clayey, sand could be found in the banks. Finally, mottled pale grey and orange, clayey, fine-grained sand can be augered in the bottom of a ditch [1934 9484] 180 m to the north.

From Sopley Common [130 975] to Ramsdown Plantation [135 965] small exposures of the Boscombe Sand are almost exclusively in fine-grained, pale brown and grey sand. The road cutting [1314 9633] on the Christchurch Road reveals 5m of fine-grained sands with ferruginous ribs. The A338 Bournemouth-Ringwood road cuts through the Boscombe Sand between Rams Down and Blackwater Hill [138 961], and a good section [1357 9644] occurs at its northern end:

	Thickness (m)
Boscombe Sand	
Sand, fine-grained, pale mauve to buff brown, laminated with muddy shaly layers up to 3cm thick; thin bituminous layers	1.20
Clay, dark grey to black, 5-cm bituminous, yellow and mauve, plastic clay at base	0.80 to 1.00
Sand, fine-grained, buff to yellowish brown, with pale brown marly clay beds up to 4cm thick; thin ferruginous ribs	0.82
Sandstone, fine-grained, brown, concretionary, some cross bedding; irregularly channeled upper surface, irregular base, strongly iron-stained in parts	0 to 0.30
Sand and sandrock, pale yellowish brown to lilac brown	0.45
Sand, coarse-grained, dark to medium brown, waterlogged; springs issue from base	0.30
Branksome Sand	
Clay, dark grey, bituminous, becoming finely laminated in depth with sandy beds up to 4mm thick	2.00

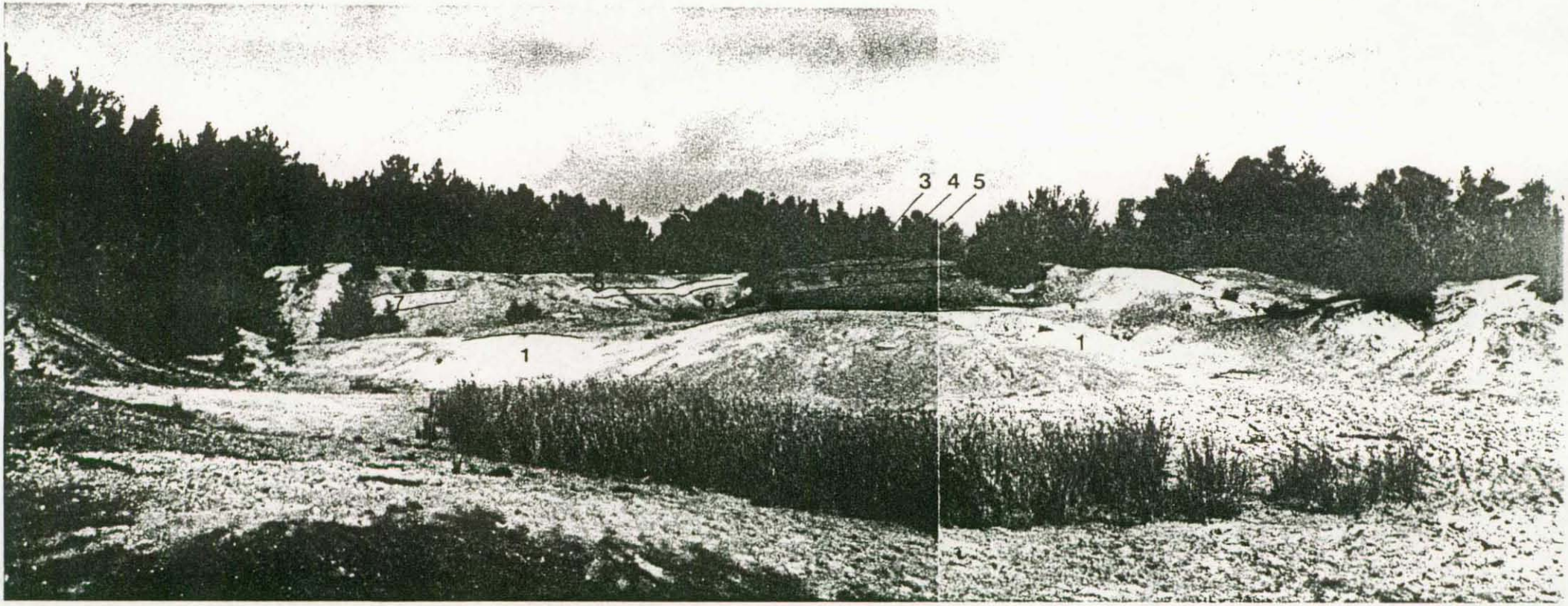


PLATE 2 Bournemouth Formation (Boscombe Sand) sands and clay, northen end of sand and gravel pit at St Catherine's Hill. Numbers refer to bed numbers in text.

A continuation of the above sequence occurs farther south in a 52-m long section [1356 9641 to 1355 9637] where 12.25m of interlaminated fine-grained, brown to lilac, sand and grey clay occur in varying proportions, but with clay predominating; some sand and sandrock intercalations are present, including 0.55m of brown sandrock and soft sandstone 2.20m above the base.

About 1km SW, the abandoned gravel and sand pit [144 957] at the summit of St Catherine's Hill provides a good section through the Boscombe Sand. The beds in the sections below are numbered as in Plate 2.

		Thickness(m)
Boscombe Sand		
Bed 8.	Sand, fine- to medium-grained reddish brown, with some harder ferruginous beds	1.00 seen
7.	Clay, pale lilac to bluish grey, 10-cm brown sandy clay at top	0.10 to 1.50
6.	Sandrock, and sand, fine-grained, brown, some cross bedding	up to 2.0
5.	Sandrock, fine-grained, pale brown, thinly bedded	0.20
4.	Sandstone, fine- to coarse-grained, hard massive, patchily red-stained	0.65
3.	Sandrock, fine-grained, locally very coarse-grained, red-stained, ferruginous layers, cross-bedded	1.20
2.	Sand, fine- to coarse-grained, red-stained	approximately 1.50
1.	Clay, white to pale grey; expands eastwards within 20m to include up to 1-m brown sand which itself thickens to the east	1.20 to 2.50

On the east side of the pit the section [1451 9567] is as follows:

PLATE 3 Bournemouth Formation (Boscombe Sand) sands and clays overlain by River Terrace Deposits; Rifle Range pit, St Catherine's Hill. The rule is 0.5m long

	Thickness (m)
2. Sand, fine- to medium-grained, with coarse-grained layers, variably cemented	1.75
1. Clay, white, silty, with thin pale brown sandy bands	2.50+

At the southern end of the deep part of the pit a third section [1447 9559] exposes:

	Thickness (m)
7. Clay, white to pale grey with pipeclay seams	1.00
6 to 3. Sand, and sandrock, fine- and medium-grained, brown, patchily red-stained	2.95

Some 360m S, a large pit [1449 9523] immediately north-west of the Rifle Range, reveals a succession that underlies those given above:

	Thickness(m)
River Terrace deposits	
Gravel, flint-rich	1.0
Boscombe Sand	
Sand, fine- to medium-grained, pale to dark brown, iron-cemented in part, with thin (1 to 5cm) white pipeclay seams (Plate 3)	3.50
Sand, fine- to medium-grained, pale brown, locally cross bedded, with harder clayey ferruginous beds	2.20
Sand, fine- to medium-grained, bright red patchy staining; staining dies out below top 1.5m	2.50
Sand, mainly fine-grained, but with very coarse-grained patches, brown, planar bedded; the base truncates the underlying beds where they are folded	1.00
Sand, mainly fine-grained, brown with sandrock and ferruginous beds; bedding contorted and displaced by small-scale penecontemporaneous folding and faulting	3.20

In an old sand pit [1453 9502], 150m S of the Rifle Range, about 7m of sands are exposed. These beds are brown, fine- to medium-grained, with some coarse-grained patches, thin ferruginous beds and local contorted bedding. Traces of grey clay are seen at the top of the section. These strata lie below those of the Rifle Range quarry, as do 4.5m of similar sand exposed in gullies at the foot of the eastern slope of St Catherine's Hill [1476 9515].

BARTON GROUP

The Barton Group includes three formations, the Barton Clay, Chama Sand and Becton Sand (Edwards and Freshney, in press). The Barton Clay locally contains a sand member, the Warren Hill Sand, whose outcrop is limited to Hengistbury Head. The Group comprises a number of upward-coarsening cycles, representing marine transgressions and regressions, some of which terminate in shore-face or beach barrier sands.

Sedimentation of the Barton Group opened with a marine transgression (Plint's (1983) T5 Trangression) which caused an abrupt fining of the sediments compared to those of the underlying Bournemouth Formation. The Barton Group coarsens upward from marine clays and sandy clays (Barton Clay), through clayey, very fine-grained sands (Chama Sand) to relatively clean, well sorted, sands (Becton Sand). Smaller transgressions occur within the Barton Clay. In most cases the shoreline facies were eroded during the transgressions, but those that remain include the Warren Hill Sand in the Barton Clay, and the Becton Sand.

The major part of the Barton Clay is made up of bioturbated shelly clays. Taken together, the fineness of grain, presence of glauconite, strong bioturbation and shelly fauna are indicative of deposition on a marine shelf below fair-weather wave base. The bases of the shelly clays tend to be fairly sharp while the tops grade up into clayey very fine-grained sands. The mean grain size, poor sorting, strong positive skewness of the grain-size distribution, bioturbation and the shelly fauna of the clayey sands (best developed in the Chama Sand) indicates deposition

below normal wave base.

The Sand coarsens upward into fine- to very fine-grained, well sorted shelly, bioturbated sand (lower part of the Becton Sand) that exhibits low positive to negative skewness. It was probably deposited on the middle to upper shoreface. The upper part of the Becton Sand marks a rapid regression. The presence of bioturbation including callianassid burrows, rootlet horizons at the top of the formation, and its grain-size and bedding characters suggest that this part of the Becton Sand was deposited in the intertidal zone. It is possible that some aeolian sand is also present.

BARTON CLAY

The formation consists of up to 70m of mainly yellow-weathering, greenish grey to olive-grey, commonly glauconitic clays, with a variable content of very fine-grained sand that occurs scattered throughout, and in discrete bands. The Barton Clay is usually heavily bioturbated with little sign of lamination. Where unweathered, the clays are commonly shelly; the upper part of the sequence is particularly rich in bivalves. A sequence of up to 10m of laminated, yellow to white, fine-grained sand, the Warren Hill Sand occurs within the top part of the Barton Clay at Hengistbury head.

No obvious variation in the bulk lithology occurs in the limited outcrop of Barton Clay in the present district.

The Barton Clay is about 39m thick at Barton-on-Sea, a few kilometres east of the present district. Estimates in the Bransgore area indicate a thickness of around 60m, and an old

water borehole at Hinton Admiral House [2084 9602] shows 70m of Barton Clay.

In the present district the formation crops out in an area stretching north from the coast at Highcliff [197 928] towards Bransgore [180 975] and Ripley [160 000], but most of the outcrop is obscured by River Terrace Deposits. A small outlier occurs at Hengistbury head.

The definition of the base of the Barton Clay has varied from author to author. In the original description (Prestwich, 1847), the base of the Barton Clay was taken at the base of the pebble bed at the base of glauconitic sandy clay at Highcliff Castle [203 931]. Keeping (1887) adopted the incoming of the foraminifer Nummulites prestwichianus at the base of the Barton Clay, an horizon about 3m above that chosen by Prestwich and within an apparently lithologically uniform glauconitic sandy clay. This latter interpretation was followed by Curry and others (1978). At Highcliff, Prestwich's basal bed of the Barton Clay consists of well rounded black flint pebbles set in a sandy, glauconitic clay. At Hengistbury, a similar clay rests on a cobble gravel at the top of the Boscombe Sand (Fig. 10, sections 1 to 4); in places the cobbles have been incorporated into the basal bed of the Barton Clay. Elsewhere (sections 5 to 7) the cobble bed is absent, and the Barton Clay rests directly on clean, very well sorted, very fine-grained, sand. This sand, up to 2m thick, also has a cobble bed locally well developed at its base. Plint (1983a, fig.2; 1983b, fig.6) regarded the base of this lower cobble bed as the base the Barton Clay.

For mapping purposes, a boundary taken at either the level of the incoming of N.prestwichianus (following Curry and others, 1978), or at the base of the lower cobble bed (following Plint, 1983a) is impractical. The present authors have therefore followed Prestwich's (1849) definition of the base of the Barton Clay because it is based on a persistent lithological character that can be traced inland.

The problem as to whether the glauconitic sandy clays at Hengistbury, are at the same stratigraphical level as similar strata exposed at Highcliff [200 929] has been the subject of much discussion since the time of Lyell (1927). The controversy was summarized by Hooker (1975). The currently accepted interpretation, first advocated by Prestwich (1849), is that both clays are at the same stratigraphical level. This was supported palaeontologically by Curry (1942) and by Costa, Downie and Eaton (1976), and by Blondeau and Pomerol (1969), working with heavy minerals.

The Barton Clay of the type section at Barton-on-Sea [235 929] contains an abundant marine fauna dominated by bivalves and gastropods; other fossils include corals, echinoids, serpulids and scaphopods and fish vertebrae. The fauna is indicative of shallow marine conditions of normal salinity. Burton (1933) divided the Barton Clay into a number of faunal and lithological divisions numbered in ascending sequence A1 to A3, and B to F. For the most part these are not mappable units, although unit A3, a grey clay with beds of fine-grained grey sand in the cliffs at Barton-on-Sea, is probably the lateral equivalent of the Warren

Hill Sand.

In the Southampton area, glauconitic sandy clays of the Barton Clay lithology occur up to 30m below the level of the earliest recorded N. prestwichianus. Palynological work by Bujak and others (1980) has shown that these clays belong to the intricatum Assemblage Zone and are thus in part equivalent in age to the Boscombe Sand of the Hurn-Christchurch district.

In the Southampton area the heavy mineral content of the lower part of the Barton Clay is characterised by alternations of a zircon-garnet-tourmaline assemblage of southern origin and a tourmaline-zircon-garnet assemblage of Cornubian origin (Morton, 1982). In the Ramnor Borehole [3114 0475], at about the level of the incoming of N. prestwichianus, Morton (pers. comm.) reported heavy minerals, including garnets and epidote, of northern and north-eastern origin which increase in importance upwards and which become dominant in the Chama Sand.

Blondeau and Pomerol (1969) studied the heavy minerals from the Barton Clay at Hengistbury. In the higher beds kyanite and garnet are more abundant than staurolite and become increasingly abundant upwards, where they are associated with a rich assemblage of epidote, anatase, brookite, hypersthene and titaniferous corundum. The presence of epidote suggested to them a correlation with part of the Lower Barton Clay at Barton on Sea. The clay minerals of Hengistbury include kaolinite (50 to 80%) with subordinate illite, although in one sample the proportions are reversed.

The upper part of the cliff at Hengistbury Head consists of very fine-grained, buff and yellow, cross-bedded sands overlain by River Terrace Deposits. They were first noted by Lyell (1827), but not named until 1879 when Gardner referred them to the Highcliff Sands on the basis of their supposed correlation with sands that crop out at Highcliff [200 929]. These latter underlie clays now referred to the Barton Clay (see above). A new name is therefore needed and the term Warren Hill Sand, after the type section at Warren Hill [1700 9050], Hengistbury is introduced here.

Although thin beds of lithologically similar sand occur in the Barton Clay beneath, and pass laterally into the Barton Clay, especially in the western part of Hengistbury Head, the base of the Warren Hill Sand appears to be sharp; the junction is only exposed in the upper part of the cliff and is inaccessible. The maximum thickness of the Warren Hill Sand is about 10m. No fauna has been recorded from the Warren Hill Sand.

Barton Clay and Warren Hill Sand Details

The Barton Clay of the cliff sections at Hengistbury have been described by many authors (Lyell, 1827; Prestwich, 1849; Gardner, 1879; Reed, 1913; White, 1917; Hooker, 1975, and Curry, 1976). A generalised section for the Barton Clay at the western end of Hengistbury head (based on Hooker, 1975) is given in Fig. 10. The Barton Clay is more arenaceous there than at the eastern end; sand beds within the clay thin and pass eastwards into sandy clays.

The bulk of the Barton Clay at Hengistbury is a glauconitic, very clayey, fine-grained sand, or very sandy clay. Beds of fine-grained sand are particularly common in the west and can be seen at several localities in the east. One such locality [1782 9040] at the top of the cliff revealed 0.7m of fine-grained, greyish buff sand above glauconitic sandy clay. Farther east, a section [1804 9052] exposed a bed of fine-grained sand, 0.5 to 1m thick, within glauconitic sandy clay and clayey sand. Small (up to 1cm) fragments of lignite are common at this locality, together with moulds of bivalves.

The clays are only sparsely fossiliferous. Nevetheless the fauna is diverse and includes fish, molluscs, echinoids, crustaceans, foraminifera, otoliths and plants (Chandler, 1960; Chapman, 1913; Curry, 1942; Hooker, 1975; Reed, 1913, and Stinton, 1975; 1977).

The ironstone nodules (Fig. 10); a characteristic feature of the Barton Clay at Hengistbury, are up to 1m in diameter and occur as impersistent layers at four levels; numbers 1, 2 and 4 persist throughout the section (Hooker, 1975, fig.4). The nodules were quarried and also collected from the foreshore for iron between 1847 and 1865 (Tylor, 1850; West, 1885). Large balls of well sorted very fine-grained sand occur in the middle part of the sequence.

Poor exposures of glauconitic sandy clay with ironstone nodules occur in the sides of the old ironstone quarry [1741 9054 to 1765 9065] at Hengistbury. Farther west, two sections in the basal beds were noted. The first [1681 9080], revealed 1m of

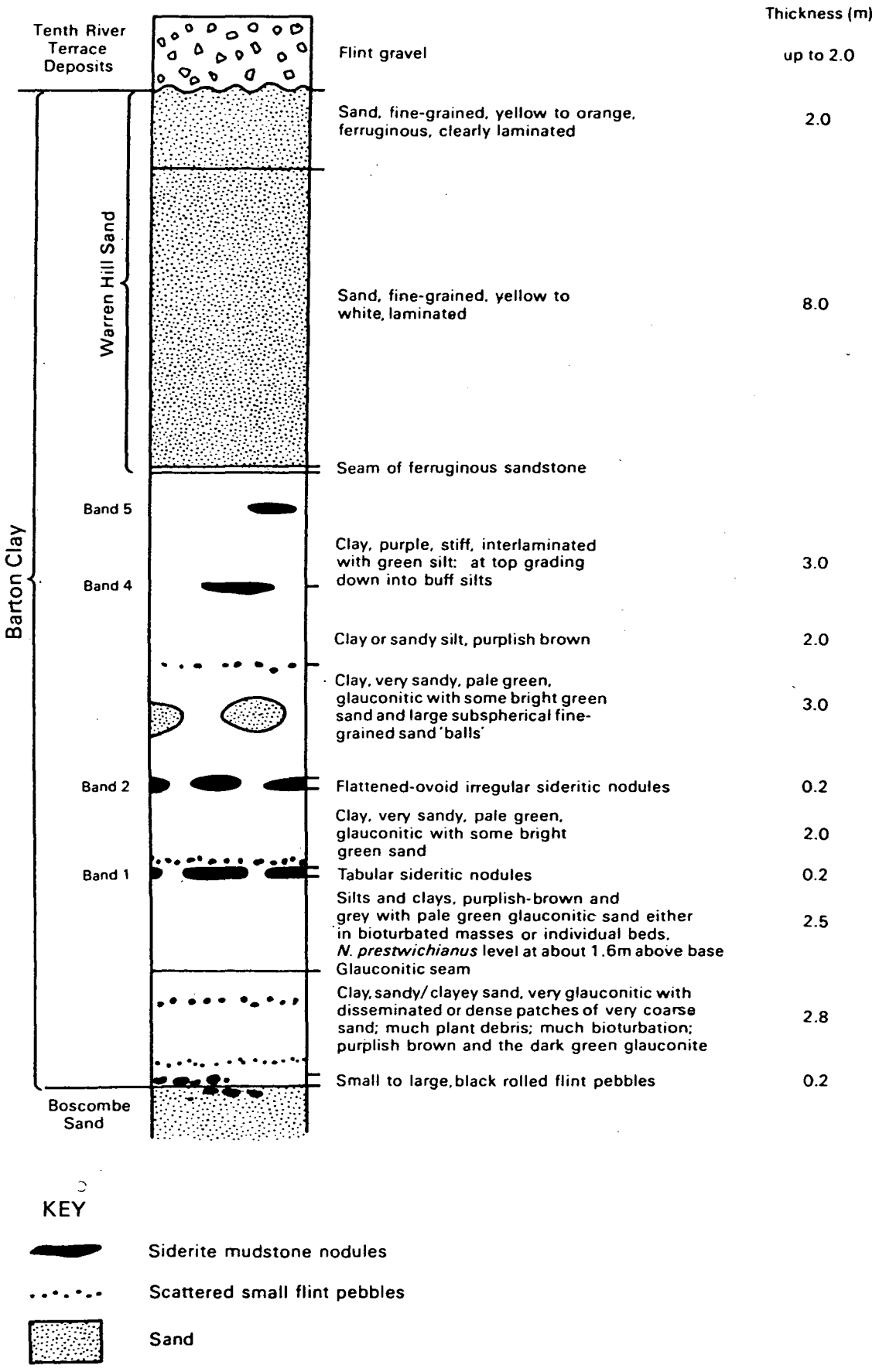


Fig. 10 Generalised section of the Barton Clay at the western end of Hengistbury Head (after Hooker, 1975).

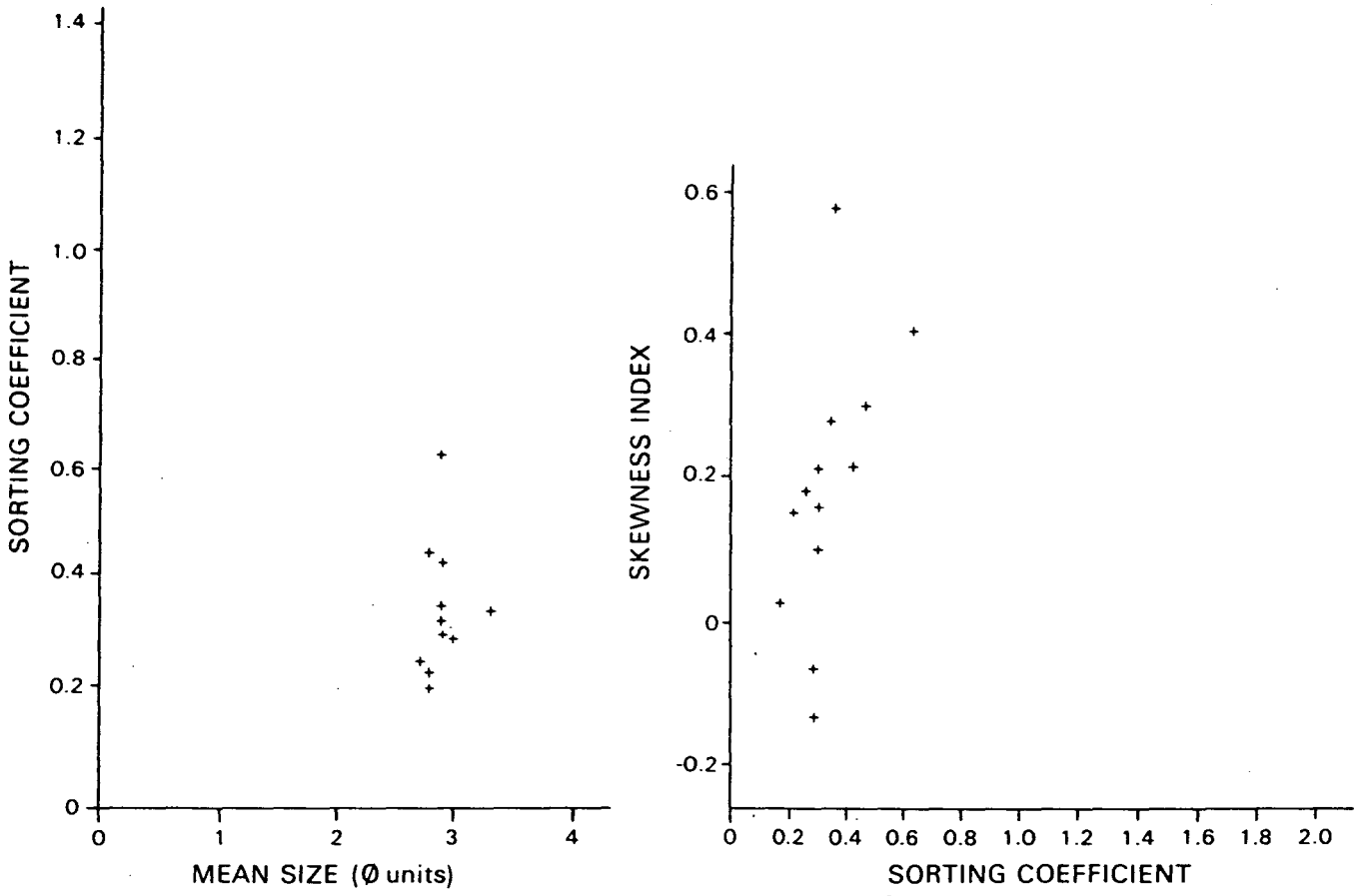


Fig. 11 Scatter plots of grain size characters from the Becton Sand of the Bransgore area.
(a)Mean size / Sorting (b) Sorting / Skewness

medium-grained, clayey glauconitic sand resting on a ferruginously cemented pebble bed, 0.1m thick, at the top of the Boscombe Sand. The second [1685 9081], exposed 0.6m of glauconitic sandy clay with a layer of small (15mm), well-rounded, black flint pebbles 0.4m above the base, resting on a pebble bed with a coarse-grained, ferruginously cemented sand matrix, 0.1 to 0.2m thick, at the top of the Boscombe Sand.

At Highcliff a maximum of 6m of glauconitic sandy clay with a basal pebble bed can be seen.

Inland, exposures of the Barton Clay are rare. Glauconitic sandy clay can be augered in the banks of the sunken path [1967 9305] near the Golf Course, and in the road banks [1952 9337 to 1959 9340] at Shelley Hill. In a railway cutting, greenish grey, clayey fine-grained sand was augered at one point [1954 9469]. The spring-line in the cutting farther east [1993 9477] probably marks the junction of River Terrace Deposits and the Barton Clay.

The BGS Burton Common No.2 Borehole [1958 9495] proved 3.17m of extremely sandy, glauconitic, greenish grey clay (Barton Clay) beneath River Terrace Deposits and above the Boscombe Sand. The nearby Burton Common No.1 Borehole [1967 9517] proved about 8m of glauconitic, extremely sandy clay (Barton Clay) resting on Boscombe Sand.

Debris from a sewerage trench [1895 9842] at Bransgore contained greenish grey, silty, slightly shelly clay. A bank below the dam of a fish pond [1848 9987], exposed 2m of yellowish grey clay. At Bransgore, Clement Reid recorded a section [1838 9776] on the 1894 6-inch to 1-mile geological map (1894) that

showed 10.0m of clay with ironstone nodules overlying 1.1m of clay. A section south of this in a stream bank [1824 9725] shows slightly glauconitic, extremely sandy clay with rounded flints at the base, overlying medium-grained sand of the Boscombe Sand.

A good section can be seen in the Warren Hill Sand in an old pit [169 9073] north-west of the Coastguard Station at Hengistbury. There, some 7m of thinly bedded and cross bedded, buff, very fine-grained sand is exposed.

CHAMA SAND

The Chama Sand consists of greenish grey to grey, slightly glauconitic, clayey silty, very fine-grained sand and extremely sandy clay; where unweathered it is commonly shelly. The formation is highly bioturbated; in places near-vertical burrows, possibly of Ophiomorpha occur. The Chama Sand forms a transitional unit between the Barton Clay and the overlying Becton Sand. The base of the Chama Sand is marked by the incoming of the slightly glauconitic, clayey silty very fine-grained sand. The junction of the Chama Sand with the Barton Clay is commonly marked by a concave topographical feature and a spring line. The formation has a narrow outcrop parallel to the Barton Clay.

The Chama Sand is estimated to be around 5m thick near Bransgore. It thickens south eastwards to 8m in the coastal sections at Becton on Sea.

The formation is too poorly exposed in the Hurn-Christchurch district to be satisfactorily sampled. However, lithologically similar samples of Chama Sand from the Southampton District have

been shown to have mean-grain-size ranging between 3.30 and 50 (25-100 μm), moderately good to very poor sorting (Sorting Index = 0.5-2.310) and grain-size distributions that are strongly positively skewed (skewness coefficient =0.5-0.80). In that district quartz grains are angular to subrounded, glauconite is subrounded, and mica is fairly common with flakes up to 200 um occuring at some levels. The heavy minerals are composed dominantly of Morton's (1982) Association A, ie, a garnet-epidote assemblage drived from a northern metamorphic basement.

The only exposure of Chama Sand within the present district is in an old pit [1992 9782] east of Bransgore where yellowish orange, slightly clayey, silty, fine-grained sand occurs beneath gravel.

BECTON SAND

The Becton Sand of the Hurn-Christchurch district forms the uppermost part of a marine regressive sequence. Just east of the district, the formation is divided into three members, but the middle, Becton Bunny Member, is impersistent; it has not been found in the present district. The upper and lower members consist of fine-grained sands and cannot be differentiated.

In surface exposures the Becton Sand consists of yellow to pale grey, well-sorted, fine-to very fine-grained sands (Average Mean Grain size 3.090). Where unweathered, the sand is greenish grey. At most localities the sand appears structureless, although some cross-bedding is present; the lower part of the sands are bioturbated and shelly. Callianassid burrows and rootlet horizons have been recorded outside the present district.

The definition of the base of the Becton Sand is arbitrary because it depends on the recognition of a gradational decrease in clay content upwards from the Chama Sand. In practice during hand augering if the sand ceases to be mouldable by hand it is considered to be sufficiently silt- and clay-free to be classified as Becton Sand.

The Becton Sand is restricted to the Bransgore area and forms fairly well-drained land. Its thickness at Bransgore is about 7m, compared with 24m at Barton on Sea.

The lighter fraction of the Becton Sand is composed dominantly of angular to subrounded quartz. The Mean size varies between 2.40 and 3.70 (75 μm - 180 μm), and the sorting between very well and moderately sorted (SO= 0.180 - 0.900) (Fig.11). The Becton Sand usually shows low positive to negative skewness values (Fig. 11). The heavy minerals (Morton, 1982) are dominated by northerly-derived material characterised by garnet and epidote.

Becton Sand Details

The Becton Sand is exposed in a small pit [1914 9940] at Bransgore where gravel wash overlies fine-grained grey sand. A piston sampler hole [1929 9941] penetrated the follcwing section:

	Depth
Gravel, orange-brown, clayey, sandy (? Made Ground)	1.95
Clay, orange-brown and grey, extremely sandy with lateritic fragments	2.85
Sand, buff to brown, clay-free, fine-grained	3.85
Sand, orange to yellow, very fine-grained	5.10
Sand, orange to yellow, fine-grained	6.70

Another piston sampler hole [1948 9939] proved 1.2m of orange to buff, fine-grained sand with rootlets beneath about 10m of Headon Formation.

Test pits [around 1960 9866] exposed several metres of buff well sorted, fine-grained sand.

HEADON FORMATION

The Headon Formation, which consists only of the lowest of the three members seen in the New Forest, crops out only in the high ground east of Bransgore. Much of the outcrop is obscured by gravel and gravel wash. At Bransgore, the formation consists of pale greenish grey, relatively sand-free, locally shelly clays, together with a considerable thickness of banded and roughly laminated very fine-grained sand, silt, and clay. The base is usually marked by carbonaceous silts commonly associated with lignite. A palaeosol is developed below these beds and the roots commonly descend into the top of the Becton Sand. It is over 16m thick near Bransgore.

The lower Headon Formation seen at Bransgore shows an increase in sand compared to that of the New Forest, but it is similar to that at Hordle Cliff near Barton on Sea. The clays of the formation generally have a low sand and silt content and are usually pale greenish grey in colour. The sand and silt grade content of the clays is commonly low, and consists mainly of subangular quartz ranging in size from 10u to 100u. Some marcasite is also locally present. Fine shell debris is commonly abundant either spread throughout the clay or as bands and laminae.

The lower part of the Headon Formation, including that part exposed in the Hurn-Christchurch area, contains a brackish to freshwater macrofauna, in which formainifera are absent. This fauna, together with a relatively high kaolinite content, the presence of palaeosols and the relationship of the Headon Formation to the underlying Becton Sand, suggest that this part of the Headon Formation was deposited in a lagoon behind a beach barrier sand. The sand beds within the Headon Formation are thought to have been derived from easterly-flowing rivers that deposited fans of sand into the lagoon and caused a local lowering of the salinity (Plint, 1983b). The silts and finer sands within the clay may either represent distal deposits from the rivers flowing in from the west, or may in part be sands derived from a marine area that lay to the southeast. Lenticular lamination (hummocky cross stratification) commonly seen in the Headon Formation may be due to winnowing by wind-generated currents.

Headon Formation Details

Exposures are poor in the Bransgore area and most information comes from a few test pits and a piston sampler hole. This last [1948 9939] showed the following section:

	Depth (m)
Headon Formation	
Clay, greenish grey, yellow-stained, sandy with diffuse bands of silt	2.00
Sand, fine-grained, orange and grey,	

bioturbated clayey	3.65
Clay, silty, greenish grey with masses of very fine-grained sand to silt	4.00
Sand, fine-grained, to silt, buff, clayey with small clay bodies	5.00
Clay, very sandy, orange, brown and grey with silt pods and lateritic layers	6.00
Sand, very fine-grained to silt, orange with rough lamination 7.2 to 7.55m	8.05
Clay, orange-stained grey, passing down rapidly into olive grey, bioturbated, extremely sandy clay	9.10
Clay, silty, dark greyish green with silt bands and pods	9.65
Clay, dark brown, carbonaceous	c 10.00

Becton Sand

Sand, fine-grained, orange to buff	1.20 seen

Test pits [around 1960 9866] showed greyish brown, sandy clay overlying fine-grained sand of the Becton Sand.

STRUCTURE

The Tertiary beds of the area are very gently folded with dips in the order of 2° or less. Very gentle rolls can be seen in the cliff sections at Southborne and Hengistbury, but the trend of the folding is difficult to discern. A contour map of the top of the Branksome Sand indicates a dip of about 1° SE in the Boscombe and Southbourne areas. In the Charminster [105 945] to Littledown [125 935] area it is possible that the dip is as high as 5° NE. Repetition of the outcrop of the Barton Clay - Boscombe Sand junction at Hengistbury Head and in the Mudeford Harbour area suggests that a WNW-trending fault or fold passes through Christchurch Harbour. Dips up to 10° on the south-west side of St Catherine's Hill may be related to the Christchurch Harbour structure. In the Sopley-Bransgore area the dip is about 1° ESE.

4.DRIFT DEPOSITS

HEAD

Head deposits in the Hurn-Christchurch district occur mainly on the valley slopes between the river terraces. They are formed from a soliflucted downwash of gravel, sand and clay from the terrace deposits, and sand and clay derived from the solid formations. Up to 6.5m of gravelly sand occurs on the slope between the 4th and 8th (locally the 9th) River Terrace Deposits between Charminster [100 946], in the north-west and Littledown [128 930] in the south-east. A borehole [1020 9444] at Charminster showed 5m of gravelly sand resting on Fourth River Terrace Deposits. A BGS flight auger hole [1209 9385] at Littledown, penetrated about 6.5m of sand and gravelly sand on terrace gravels. The spread [146 960] of Head which overlies Third Terrace Deposits on the east side of St Catherine's Hill, is composed of clayey sand with a variable gravel content. This deposit also incorporates material derived as rainwash.

A small fan-shaped, largely vegetation-free area of colluvial material has been mapped as Head on the north side of Hengistbury Head [1772 9075]. It consists dominantly of sand and is a modern deposit which presumably originated during the working of the ironstones in the quarry nearby. It formed during periods of heavy rain when sheet flooding of sand-charged water crossed an area of Made Ground and debouched onto the flat surface of the River Terrace Deposits. The process continues today; deposition is sufficiently vigorous to stifle all but the hardiest or most rapidly growing plants.

Head deposits, mainly sandy gravel, occupy the floors of the small steep-sided valleys near Boscombe [107 918 and 126 916] which are cut in the gravel terraces.

RIVER TERRACE DEPOSITS

River Terrace Deposits laid down mainly by the rivers Avon and Stour have been recognised at fourteen levels within the present district. They range in height from 0.5m to 71m above the alluvial plain and have been numbered one to fourteen in ascending order. The higher terraces, from the fifth to fourteenth, are difficult to relate to the present courses of the rivers and may have been associated with an earlier drainage system involving a River Solent (Reid, 1902).The larger areas of First to Fourth River Terrace Deposits bordering the Stour and Avon are clearly related to these rivers. Terrace 1 has only a limited outcrop area, being below the Alluvium in the lower reaches of the river. The numbering of the terraces in the present survey differs from that of Clarke (1981)for the upper reaches of the Avon and Stour. This is due to the introduction of lower terraces in the south (not seen by Clarke), and the recognition of a number of higher terraces based on geomorphological flats, particularly in the Bransgore area.

The deposits consist mainly of flint gravel with small proportions of chert, 'sarsen' stone, and limestones probably of Jurassic age. The gravel is commonly very sandy; the maximum pebble size is usually around 5cm. The pebbles are usually subangular to subrounded, but in places, if there is a nearby

source of Tertiary gravel such as at Hengistbury Head, there can be a considerable proportion of well-rounded pebbles reworked into the more recent gravels. The First to Fourth River Terrace Deposits may be covered by up to 1.5m of silty clay to clayey fine-grained sand.

The thickness of the River Terrace Deposits is highly variable and may be as much as 8m or more in the First and Second Terrace Deposits and as little as 1m in some of the higher levels, such as the Tenth River Terrace Deposits. Most of the higher deposits, down to the Third River Terrace Deposits or below, show signs of cryoturbation, usually in the form of an irregular fabric in the gravels with involution and flame structures.

Implements of Acheulian type have been found in the Sixth to Eleventh River Terrace deposits (White, 1917) thus suggesting a Middle Pleistocene age for these terraces, although some of the lower occurrences may be reworked material. Submarine terraces occur in the east Solent and these are probably late Upper Pleistocene in age, ranging up into the Flandrian.

River Terrace details

Fourteenth River Terrace Deposits

Limited outcrops of this terrace occur north-east of Bransgore where the maximum thickness is about 3m; the surface of the deposit is about 75m AOD. One pit [1902 9966] showed over 2.5m of orange-brown and grey gravel with cobbles up to 10cm in size. Some layers of medium- to coarse-grained sand also occur.

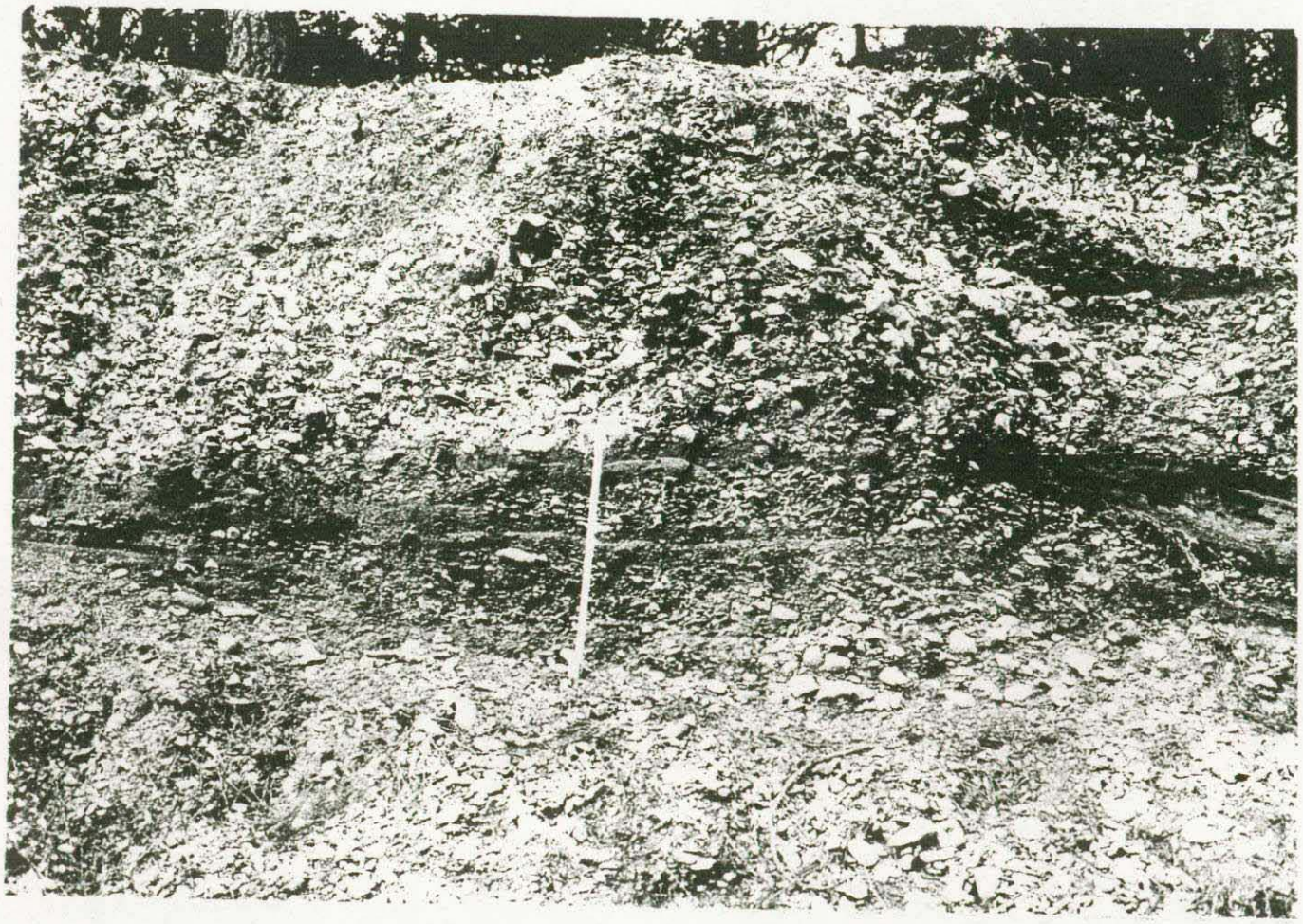


PLATE 4 Cryoturbated Eleventh River Terrace gravels, St Catherine's Hill

Thirteenth River Terrace Deposits

Deposits of this interval occur at Bransgore where they have a surface level of about 62m AOD. An old gravel pit [1965 9852], 400m NE of Bransgore House, shows over 3m of ferruginous gravel with clayey sand layers.

Twelth River Terrace Deposits

Deposits of this terrace only occur near Bransgore where they have a surface level of about 55m AOD. A borehole [1823 9565] proved 0.6m of sandy loam overlying 5.1m of fine to coarse, subangular gravel with some sand.

Eleventh River Terrace Deposits

Deposits of this terrace comprise the large flat at the summit of St Catherine's Hill [144 955], and three small spreads at Blackwater Hill [138 961] and Ramsdown Plantation [135 955]. Another spread of this terrace occurs east of Bransgore [196 978]. The upper surface of all these occurrences is about 45m AOD, some 42m above the floodplain. At St Catherine's Hill the deposits have a maximum thickness of 2.8m, and are best seen in the face in the north-western part of the old sand and gravel pit [1432 9581]. There 1.95m of sandy gravel was recorded. The gravel was mostly fine with some coarse, subrounded flint, some fine well rounded flint and vein quartz, set in a matrix of dominantly medium-grained, but with some fine- and coarse-grained, subangular to subrounded, quartz and flint sand and silty sand. The deposit is patchily leached, and generally cryoturbated (Plate 4].

Tenth River Terrace Deposits

A spread of sand and gravel 0.5km SW of Queen's Park Golf Course has a surface level of about 40m AOD. A well [1023 9278] in this spread penetrated 0.6m of Made Ground, resting on 2.74m of gravel, which rested on yellow sand of the Boscombe Sand.

A single spread of gravel on the top of Hengistbury Head [1710 9067] has been assigned to this terrace. The top of the terrace lies at about 37m AOD; the maximum thickness is about 1.5m.

Ninth River Terrace Deposits

At Springbourne [around 110 920] spreads of sand and gravel have an upper surface at about 35m AOD. A borehole [1043 9256] at Springbourne penetrated 4m of gravel with pebbles up to 50mm, resting on sands with bands of brown clay of the top Branksome Sand. Another borehole [1194 9205], 150m E of the above, proved the following section:

	Depth (m)
River Terrace Deposits	
Sand, brown and orange, silty with scattered gravel	0.76
Sand, yellow, with small pockets of clay	1.07
Boscombe Sand	
Sand, light yellow	

Eighth River Terrace Deposits

Spreads of sand and gravel of this terrace occur at Littledown [117 935], Southbourne [146 915], near Bransgore [190 968] and near Hinton Admiral [200 950]. The surface level falls eastwards from about 27m AOD at Southbourne to about 23m AOD at the coast. The surface also falls southwards down the Avon Valley from about 35m AOD, some 22m above the floodplain, at North Ripley to 23m AOD at the coast.

A test pit [1196 9350] at Littledown showed 0.2m of topsoil overlying 1.05m of orange sandy gravel, which in turn rests on yellow, medium-grained sand of the Boscombe Sand. Farther east in the Southbourne area [1461 9154] a borehole showed 0.76m of Made Ground overlying 2.13m of gravel and sand, which in turn overlay yellow sand of the Boscombe Sand. A borehole [1237, 9332] at Porchester School penetrated 1.45m of dark yellowish brown, sandy gravel resting on sands of the Boscombe sand.

Deposits of the Eighth Terrace have been worked in a number of localities in the Avon Valley; the thickness of the deposits appears to be about 4.5m. A borehole [1905 9685] in the east of the district proved:

	Depth (m)
Topsoil	
Sandy loam with scattered flints	0.5
River Terrace Deposits	
Gravel, fine and coarse, subangular to subrounded with some sand; scattered subrounded flint cobbles below 3.5	4.4

Barton Clay

Clay, sandy

A second borehole]1952 9627] proved:

	Depth (m)
River Terrace Deposits	
Sand, peaty, dark brown	0.3
Gravel, fine and coarse, subangular with sand	4.6
Barton Clay	
Clay, sandy	

Gravel was formerly worked in a large pit [198 946] west of Hinton Admiral Station. The pit was about 2.5 to 3m deep, but all that is visible today is medium- to coarse-grained, glauconitic sand beneath 1m of gravel [1990 9453]. In the Burton Common No.2 Borehole [1958 9495], 2.43m of sand and gravel, with pebbles 2 to 3cm in diameter, and a sand layer between 1.8 and 2m, overlie 0.97m of sand, which in turn rests on 2.03m of sandy gravel with pebbles up to 5cm diameter.

In the cliff sections at Friar's Cliff [1980 9287] the gravel is up to 1.5m thick; the base is strongly cryoturbated.

Seventh River Terrace Deposits

A small area of sandy gravel of the Seventh River Terrace occurs west of Fillybrook Bottom [127 996]. The degraded top is about 15m above the floodplain (20m AOD). The deposit has a variable thickness, but probably does not exceed 1.5m. The area

west of here, Hurn Forest [120 995], bears an impersistent thin skin of cryoturbated gravel up to 1m thick, possibly the remnant of a once more extensive terrace. These gravels have a poorly developed planar top in places.

Sixth River Terrace Deposits

Berry Hill [107 960] is capped by a small area of Sixth River Terrace Deposits. The top of the hill is about 17m AOD, some 12m above the floodplain. A borehole [1073 9588] near the edge of the terrace proved 0.91m of sand and gravel; the maximum thickness is probably 1.5m.

Sand and gravel, with a surface level of about 15m AOD and a base level of about 12m AOD, occurs at the eastern end of Hengistbury Head where it has a maximum thickness of about 3m. The base is locally very irregular due to cryoturbation. A section [1729 9056] at the western end of the terrace, shows 3m of sand and gravel including a 1-m thick bed of laminated sand in the middle.

Fifth River Terrace Deposits

The largest area of the Fifth River Terrace Deposits borders the River Avon. It is the most widespread of the Avon terraces having an outcrop width of over 2km and extending over 13km along the Avon within the present district. The surface level falls from 14m AOD in the north [northing 00] to 6m AOD near the coast at Mudeford.

A borehole [1550 9964] towards the northern margin of the district proved 1m of brickearth consisting of sandy silty clay, resting on 2.1m of fine and coarse, subangular to subrounded, gravel with medium- to coarse-grained sand, above dark grey silty clay of the Branksome Sand. Another borehole [1637 9644], showed 1m of fine-grained sandy clay overlying 6m of sandy gravel, the gravel being fine with coarse subangular and subrounded flint. A third borehole [1763 9851] proved 0.7m of silty clay over 7.8m of sandy gravel. Farther south [1823 9565], 0.6m of sandy loam overlies 5.1m of fine to coarse, subangular gravel in a matrix of medium- to coarse-grained sand.

Few figures are available for the full thickness of the deposits in the southern part of the outcrop. Excavations for new houses [1892 9384] near Somerford proved at least 7m of gravel. Farther south at Mudeford County Junior School [1773 9260], boreholes proved 2.85m of sandy gravel without penetrating the deposit. In the west a borehole [1666 9479] proved 5.33m of sandy cobbly gravel above the Bournemouth Formation. Only 2.59m of gravel were present in another borehole [1679 9433]

Fourth River Terrace Deposits

Fourth Terrace gravels occupy a large area around Throop [111 955], and there the terrace is divided into two stages, 4a and 4b. The top of 4a is at about 12m AOD (7m above the floodplain), and 4b at 12.5 to 13m AOD. The intervening feature, although small, is quite clearly developed. Two boreholes lie within this outcrop, the first [1046 9520], is near Castle Nursery:

	Depth (m)	
Made ground	0.80	
Brickearth		
Sand, very clayey	2.80	
Fourth (4b) River Terrace Deposits		
Gravel, fine- and coarse-grained, subangular to subrounded, mainly flint, in a matrix of chiefly fine-grained sand	4.80	
Bournemouth Formation	to	7.80

The Brickearth recorded in this borehole is unusually thick; patches of silty sand and clay, often with scattered patinated subangular flints at the surface, have been noted in several places in the area, but have not been mapped separately from the gravels. The usual thickness is less than 1m.

The second borehole near Throop [1154 9542] is as follows:

	Depth (m)	
Soil and subsoil	0.80	
Fourth (4a) River Terrace Deposits		
Gravel, fine with coarse subangular to subrounded flint, vein-quartz and sandstone in a matrix of chiefly medium-grained sand	5.20	
Bournemouth Formation	to	8.00

On the opposite (north) side of the Stour a degraded Fourth Terrace remnant (possibly 4b) occurs north and west of Merritown Farm, the top is about 13m above OD (8m above the floodplain).There is an extensive outcrop of Fourth Terrace (4a)

in and around Hurn Airport, with the top of the deposit at about 11m above OD (6m above floodplain). There are remnants of old workings in the northern part of the spread, and at one of them [1045 9914], proved 0.2m of brownish grey flinty loam ('Brickearth') on 2.2m of sandy fine-grained gravel. Three boreholes provide details of this deposit; the first [083 9947] at East Parley Common, proved:

	Depth (m)
Top Soil	0.10
Brickearth	
Sand, pebbly	0.50
Fourth River Terrace Deposits	
Gravel, fine with some coarse subangular to subrounded chiefly flint, in a matrix of medium-grained sand	4.10
Bournemouth Formation to	9.60

The second at Bournemouth (Hurn) Airport [1024 9836], proved:

	Depth (m)
Made Ground and Soil	0.40
Brickearth	
Sand, clayey and pebbly	0.90
Fourth (4a) River Terrace Deposits	
Gravel, fine with some coarse subangular to subrounded flint, with rare quartz and sandstone, in matrix of medium- and coarse-grained sand	3.80

The third borehole at West Hurn [1183 9723], proved:

		Depth (m)
Topsoil		1.20
Fourth River Terrace Deposits		
Gravel, fine with some coarse subangular to subrounded flint, in matrix of medium-grained sand		3.40
Bournemouth Formation	to	6.00

To the south, in and around the urban area, the following sections are typical; a trial pit north-east of Strouden [1187 9488] proved:

		Depth (m)
Fourth River Terrace Deposits		
Sand, loamy, dark brown, with, fine to medium gravel		0.55
Sand, dark brown with much gravel		0.15
Gravel, coarse to medium with medium-grained sand, medium dense, yellowish brown		2.00
Bournemouth Formation	seen to	2.30

A borehole [1071 9499] north of Strouden proved, beneath 0.9m of soil and sandy clayey silt, 2.55m of dense to very dense, fine-to medium- and coarse-grained sand, together with fine, medium and coarse gravel resting on grey laminated clays of the Branksome Sand. A borehole [1454 9211] penetrated 0.9m and brown sand and rough gravel above silt and sand of the Boscombe

Sand. A third [1388 9205] encountered 3.66m yellow sand and fine gravel, overlain by 3.5m of sand and clay of probable solifluction origin. A BGS auger hole [1230 9397] proved:

	Depth (m)
Fourth River Terrace Deposits	
Sand, gravelly with some large flints up 70mm across at base, yellow	1.30
Boscombe Sand	
Sand, fine- to medium-grained, slightly clayey, yellow to buff	to 20.44

Christchurch and Southbourne and their suburbs are built on gravels of the Fourth Terrace. Its surface falls from 8m AOD in the north to 4m AOD at Christchurch. These deposits were formerly dug for sand and gravel in a number of pits [1503 9457, 1535 9450, 152 940, 1525 9367 and 1540 9355] north of the railway line. Most of the pits, generally 2 to 3m deep, are degraded or built over and no longer have sections exposed. In one pit [152 940], however, up to 2.5m of medium flint gravel is exposed along part of the north-eastern face.

Trial boreholes for the Christchurch Central Redevelopment [around 158 929] proved thicknesses between 2 and 3.3m of sand and gravel. The base level of the terrace in this area is about 2m AOD.

On the south side of the River Stour, thicknesses of 4.2m [1564 9132] and 2.90m [1535 9160], with base levels of 2.8 and 4.87m respectively, have been proved.

Third River Terrace Deposits

Gravels and sands of Third Terrace age form extensive spreads in the valleys of the Stour, Avon, and Moors rivers. On the west side of the Moors River a tract of Third Terrace extends southwards onto the north side of Stour at 8 to 9m AOD (3 to 4m above the floodplain). Two boreholes provide sections through this deposit; the first [1141 9902], at Merritown Heath proved:

	Depth (m)
Topsoil	0.10
Brickearth	
Sand, clayey and pebbly	0.60
Third River Terrace Deposits	
Gravel, fine and coarse, subangular to subrounded flint, traces of quartz and sandstone in a matrix of coarse-grained sand	5.70
Bournemouth Formation	to 8.70

The second borehole [1202 9778] at Sussex Farm proved:

	Depth (m)
Topsoil	0.60
Third River Terrace Deposits	
Gravel, fine- with coarse-grained subangular to subrounded flint, traces of quartz and sandstone, in a matrix of fine-grained sand	5.30
Bournemouth Formation	to 8.30

A complementary narrow spread of Third Terrace occupies the east side of the Moors River [135 975]. Small tracts of this deposit occur higher up the Stour valley, west of Merritown Farm [105 973] and north of Berry Hill [105 965]. In the small spread at Holdenhurst 1.6m of sandy, fine- to coarse-grained gravel were seen in a roadside exposure [1240 9526] in Holdenhurst Road.

On the east side of St Catherine's Hill, and between it and the Avon, lies an elongated spread of Third Terrace Deposits. The surface is at an average height of about 8 to 9m above OD (3 to 4m above the floodplain), but is rather hummocky. It is possible that small patches of blown sand contribute to this uneven surface, but they cannot be mapped with any certainty. There is also a skin of downwash derived from the Bournemouth Formation of St Catherine's Hill. This Terrace is penetrated by a borehole [1401 9674], at Ramsdown Plantation:

	Depth (m)
Brickearth	
Sand, clayey	1.00
Third River Terrace Deposits	
Gravel, fine with coarse subangular to subrounded flint, with matrix of medium-grained sand	4.40
Bournemouth Formation	to 7.40

Third River Terrace Deposits occur south of the Stour/Avon at Wick [157 917]. Other remnants are to be found at Burton [164

945 and 168 928] and Crouch Hill in Stanpit Marshes [170 919]. The surface level of the terrace falls from about 6m AOD in the north to about 3m AOD in the south.

In the Burton area the thickness of the deposit exceeds 3m, but no detail is available for the other spreads. Grading figures show a sand:gravel ratio of 45:55 [1637 9399]. The gravel was formerly worked at Wick [1565 9175].

Second River Terrace Deposits

Deposits of Second River Terrace occur as scattered fragments, some 0.9 to 1m above the floodplain, along the River Avon, and as more extensive flats on either side of the Stour.

In the Stour valley, a small patch of gravel was penetrated by a borehole [1024 9731] at Parley Green

	Depth (m)
Topsoil	0.10
Second River Terrace Deposits	
Gravel, fine and coarse, subangular to subrounded flint, with a matrix of medium-grained lignitic sand	2.70
Bournemouth Formation	to 5.70

About 2km downstream a large spread of Second Terrace borders the Stour Alluvium around Hurn Court [122 955], and three small terraces are found in the Moors valley [125 985 and 127 964]. East of Holdenhurst a spread of Second Terrace lies on each side of the Stour [128 952] and [138 950]. In the valley of the

River Avon, Second Terrace Deposits form three small areas of gravel which lie within the alluvial belt. At the northernmost of these [1380 9914], 1.20m of gravelly, brownish grey sand were seen to overlie 0.2m of fine-grained gravel. The deposit also occurs as spreads flanking the Alluvium on the west side of the Avon, and these spreads are the sites of two boreholes; the first at Week Common [1343 9953] proved:

		Depth (m)
Topsoil		0.20
Brickearth		
Sand, very clayey		0.90
Second River Terrace Deposits		
Gravel, fine and coarse, subangular to subrounded flint, with matrix of medium-grained sand		6.80
Bournemouth Formation	to	9.70

The second at Pithouse Farm [1372 9836] proved:

		Depth (m)
Topsoil		0.20
Second River Terrace Deposits		
Gravel, coarse and fine subangular to subrounded flint, in matrix of medium-grained sand		6.60
Bournemouth Formation	to	9.60

Boreholes in the Purewell area [around 169 930] proved thicknesses of gravel ranging from 5.8 to more than 6.3m. Another borehole [1666 9285], 300m SW of the above, proved 5.2m of compact gravel.

First River Terrace Deposits

First River Terrace Deposits have a patchy distribution principally along the River Avon. The surface of these deposits is at floodplain level, consequently although the surface is wet and may have a thin skin of organic material, it is firm underfoot.

North of Purewell the thickness of the deposits exceeds 3.6m [1653 9374]. Grading figures for the deposits near the railway line show that it is dominantly a medium gravel, with the sand content varying from 0 to 55% [1655 9372 and 1653 9374].

On Stanpit Marshes thicknesses of 10.5m [1715 9235], 8.6m [1687 9212] and 5.4m [1958 9495] of terrace deposits have been proved.

At Wick, on the opposite side of the river, the original thickness of the sand and gravel (before partially covered with Made Ground) varies between 4.27m [1606 9170] and 6.7m [1599 9188], with base levels of 4.47 and 6.4m below OD respectively.

The Hengistbury No.3 Borehole [1805 9072] proved about 17.5m of First Terrace sand and gravel above Branksome Sand, although, because of poor sample recovery, precise thicknesses of the various lithologies could not be ascertained.

ALLUVIUM AND ESTUARINE ALLUVIUM

The Alluvium of the floodplain of the Stour, Moors, and Avon rivers consists of an upper unit of mottled dark grey and orange, commonly organic, silts, silty clays and clayey sands, resting on a lower unit of sand and gravel. In the lower reaches of the Avon and Stour, the Alluvium merges imperceptibly into Estuarine Alluvium. In the Hurn area the thickness varies from 0.5m [1427 9941] to 1.5m [1170 9637]. Farther south, near Iford Bridge [1338 9430], the Alluvium consists of 2m of clayey coarse-grained sand with flint grains, overlying more than 1m of sandy clay and clayey sand with gravel layers.

Along the River Avon south-west of Sopley a borehole [1529 9657] showed 0.2m of peaty loam overlying 0.4m of soft, sandy silty mottled orange and grey clay resting on gravel.

North of Christchurch, the upper unit of clayey peat varies from 0.3m to more than 1.2m; the thickness of the alluvial gravel was proved at only one point [1561 9360] where it was 4.4m thick. Boreholes [between 1583 9303 and 1593 9290] on the east side of Christchurch proved, beneath Made Ground and ?Head, 1.3 to 3m of peaty alluvial clay, resting on 2 to 3.5m of alluvial gravel. Towards Purewell the thickness of black silty clay above gravel varies from 0.5 to 0.9m [around 163 927]. South of Christchurch, thicknesses in excess of 1.2m of black peaty clay were consistently augered.

PEAT

A small spread of peat occurs [117 985] on the north side of the Alluvium of the Moors River, and is about 0.75m thick.

STORM GRAVEL BEACH DEPOSITS

The most extensive of the storm gravels in the district extends north-north-eastwards from Hengistbury Head, and almost closes the mouth of Christchurch Harbour. Burton (1931] has documented the changes in the extent of the spit and the former positions of The Run. At its maximum, in 1880, it extended almost to Cliff End [c 198 927], approximately 1.8km NE of its position in 1847, and 1km beyond its present position.

Minor gravel spits occur at several localities around Christchurch Harbour. Some are up to 500m long [166 917 and 176 910], but are generally not more than 1m high. However, at one point at the latter locality [1765 9100] the ridge is 3m high, although possibly its height is augmented with Blown Sand.

BLOWN SAND

Two ages of Blown Sand occur in the district. The more recent occurs on cliff tops and consists of sand blown up the face and deposited in an area of slackening wind velocity just behind the cliff tops. It is still accumulating where not built on. It is well developed between Boscombe Pier [112 912] and Southbourne [148 913], to the west of Hengistbury Head [112 912] and Southbourne [148 913], to the west of Hengistbury Head [159 910], and on top of Hengistbury Head [1725 9050]. A borehole [1255 9142] at Boscombe showed 2.44m of Blown Sand on terrace deposits.

Blown Sand also occurs on top of some of the lower river terrace gravels. One deposit, on Crouch Hill in Stanpit Marshes [170 919], rests on Third River Terrace Deposits; another, in the valley of the River Avon near Dudmoor Farm [1500 9600], rests on Second River Terrace Deposits. This latter deposit is at least 3m thick and consists of well sorted, fine-grained sand. It was probably derived from sand from St Catherine's Hill blown by the prevailing wind; deposition seems to have ceased.

Blown Sand overlies the shingle spit which extends NNE from Hengistbury Head. Burton (1931) recorded that the dunes on the spit had been up to about 5m high, but that their height was much reduced by "trampling feet".

MADE GROUND

Extensive areas of marshland and low-lying ground bordering the rivers have been reclaimed, especially so in recent years. The NW part of the Recreation Ground, Purewell [165 925], and an area 500m and 300m has been raised about 2m, presumably using household refuse. South-west of Wick an area 800m by 400m [around 162 916] has been built up by an estimated 1.5m. Similarly the Recreation Ground, Wick [162 916], and some of the older parts of Christchurch [162 924 and 1625 9270], have been raised by 1 to 2m.

Farther up the Stour, areas of Made Ground occur on Alluvium near Tuckton [146 925, 143 932 and 142 935]. Most of the material appears to be constructional waste, rather than household refuse. Other older areas of fill occupy old brick-pits [116 927, 106 933, 102 934, 101 933 and 105 920] in the Queen's Park and King's Park areas. These pits probably contain some household refuse; most of them are now built over.

The known areas of Made Ground and their presumed composition are shown in Fig. 18.

ECONOMIC GEOLOGY

SAND AND GRAVEL

Extensive areas of gravel occur in the terrace deposits of the Rivers Stour and Avon. The areas with the biggest resources are those underlain by Fourth and Fifth River Terrace deposits, but in the lower reaches of the rivers, those of the First to Third terraces become more important. The higher terraces (sixth to fourteenth) are commonly of limited extent, or are built over, and do not form a potential resource. An exception is the Eighth River Terrace Deposits which are well developed in the Bransgore to Hinton Admiral area where they have been extensively exploited.

The sand and gravel deposits of the north part of the district (sheets SZ 19 NW and 19 NE) have been studied and the resources estimated by Clarke (1981).

The present report includes Clarke's resource blocks B and parts of A, C, D, E, and F, the most important tonnage being blocks B, C, and F. Blocks B and C border the River Avon and F the Rivers Stow and Moor. The approximate resource tonnage in that part of SZ 19 covered by Clarke (1981) is likely to be in the order of 160 million tonnes.

The resources of sheets SZ 19 SW and 19 SE are now mostly sterilised by urban development. This trend is likely to continue, particularly in the Littledown- Holdenhurst area. The only remaining sizeable tract of open ground within the district underlain by gravel lies north of the railway line east of

Burton, and north of Christchurch [around 180 945]. The total thickness of the deposit in this area is unknown; estimates from boreholes to the north, and site investigations near Somerford to the south, suggest a range of thickness between 3 and 7m, with an overburden of up to 1.5m.

SAND

The dominant lithology of the Bournemouth Formation is sand, but that of the Boscombe Sand, which forms the most extensive outcrop, is too fine-grained for use in the building industry. Some coarser-grained sands occur in the Boscombe Sand in the St Catherine's Hill area, and some of this material may be suitabnle for building sand.

In the past, other sands such as the Chama Sand and Becton Sand have been worked for moulding sand and glass sand respectively in areas east of the Hurn-Christchurch district but it is unlikely that such sources would be suitable for today's uses.

BRICK CLAYS

Three different stratigraphical units have been worked for brick clays. These are the Headon Formation, the Barton Clay and the clays at the top of the Branksome Sand.

Old pits in greenish grey clays of the Headon Formation occur near Bransgore [1965 9920 and 1957 9914]. The Barton Clay was also worked at Bransgore [1894 9847, 1835 9790 and 1925 9792]. Old pits in the clays in the Branksome Sand in the King's Park [1165 9270] and Queen's Park [1055 9330 and 1020 9340] areas

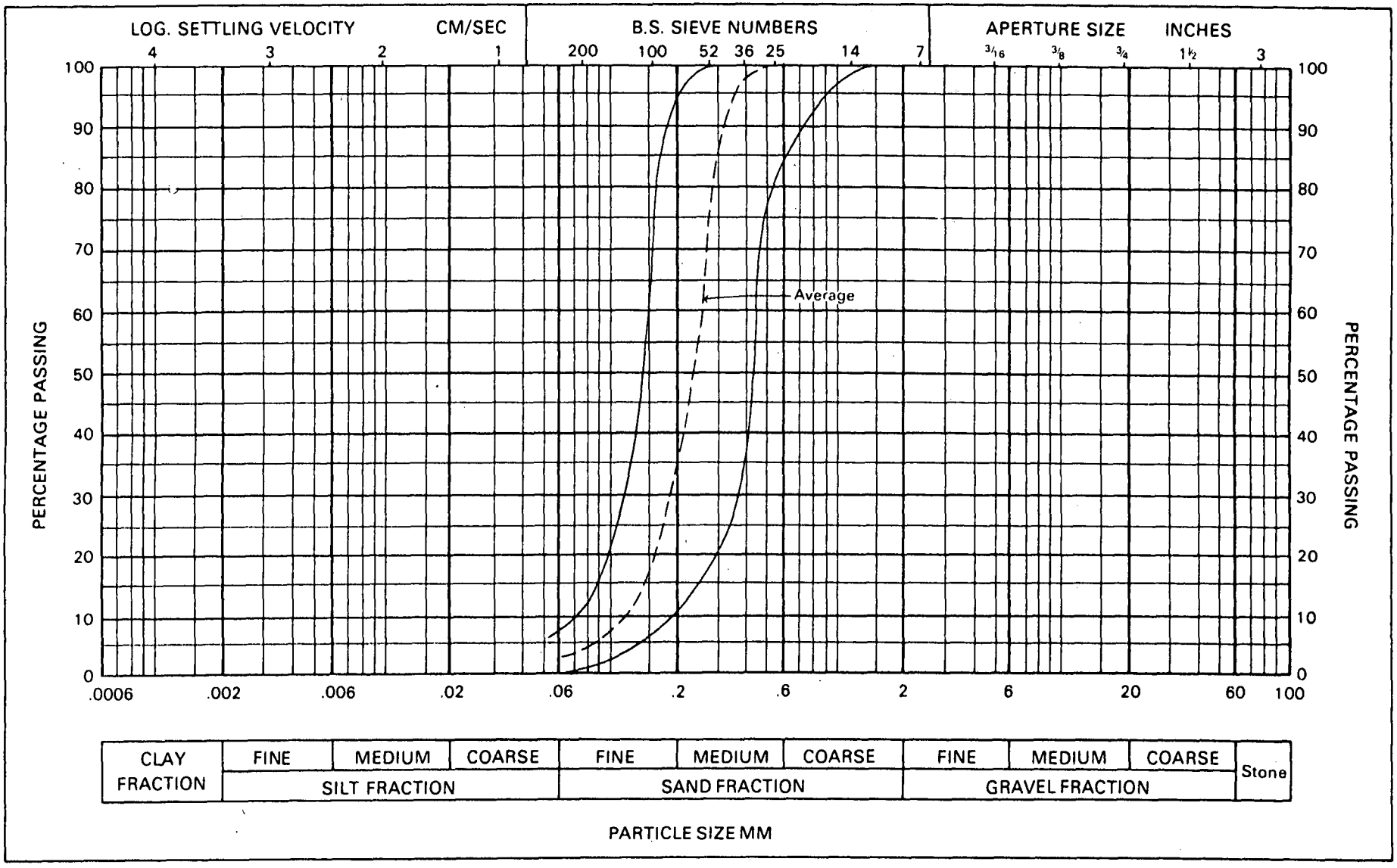


Fig. 12 Grading curve envelope for sands of the Bournemouth Formation of sheet SZ 19 NW.

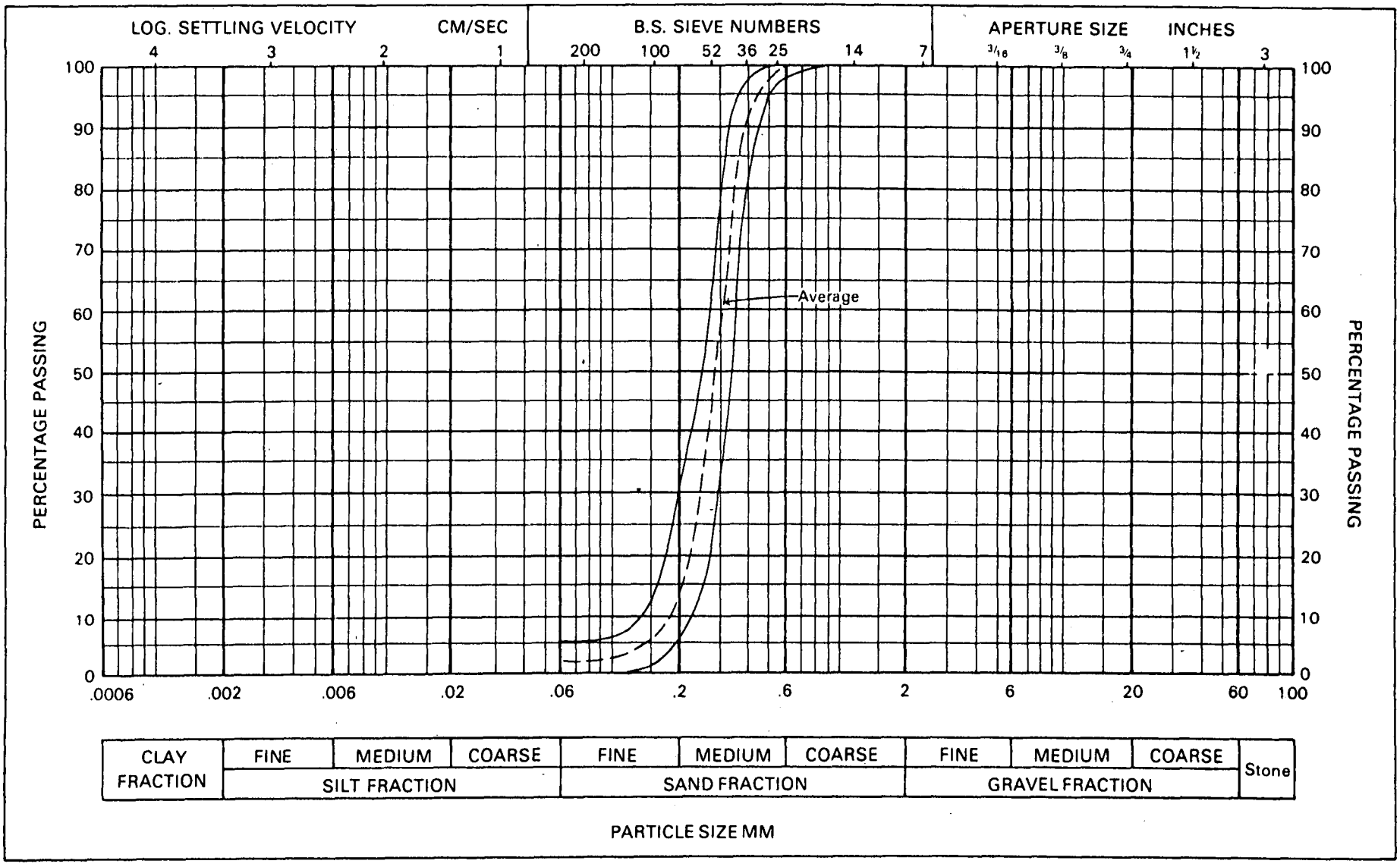


Fig. 13 Grading curve envelope for sands of the Bournemouth Formation of Sheet SZ 19 NE.

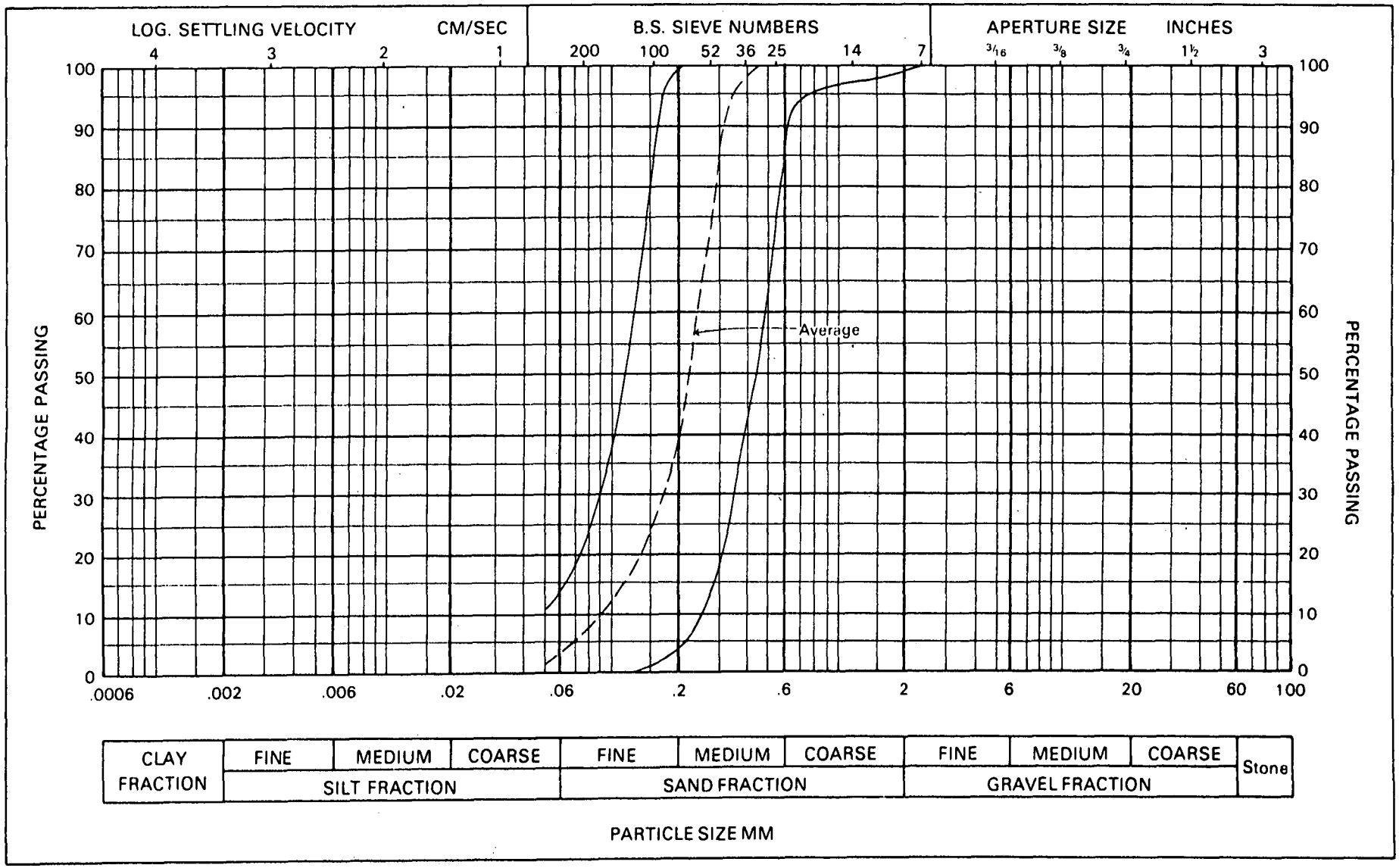


Fig. 14 Grading curve envelope for sands of the Bournemouth Formation of Sheet SZ 19 SW.

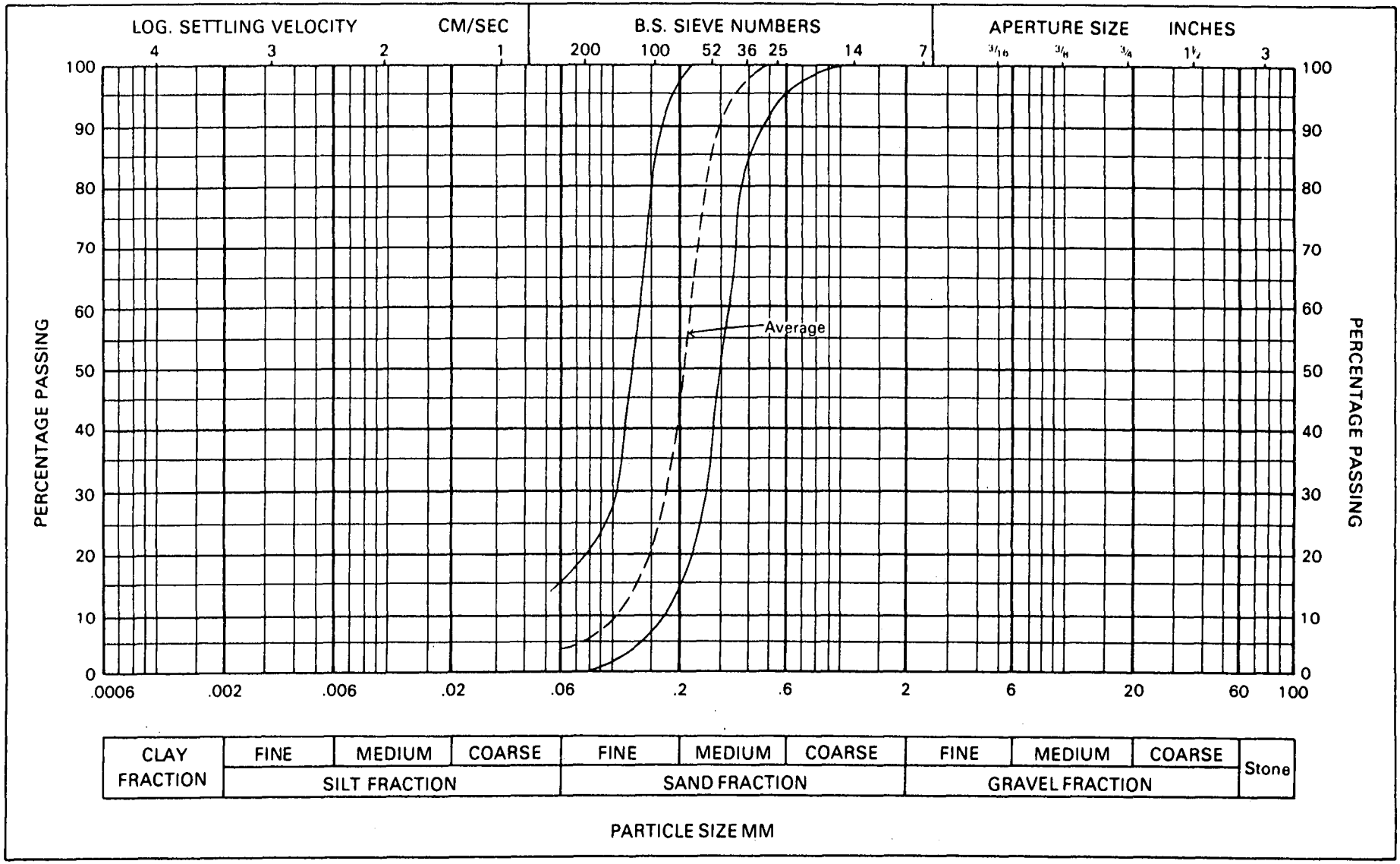


Fig. 15 Grading curve envelope for sands of the Bournemouth Formation of Sheet SZ 19 SE.

of Bournemouth, are now built over. Other pits operated nearer the town centre [105 920]. These clays are lithologically too variable and too discontinuous to be considered as modern sources of brick clay.

ENGINEERING GEOLOGY

The soils of the area are mainly of a granular nature, coarse in the case of the river terrace gravels and finer in the case of the Bournemouth Formation. The terrace gravels are usually compact, well graded and are commonly over 2m thick. They therefore provide adequate foundations for most small to medium-sized structures. The lower river terraces (First to Fourth) commonly have a cover of silty clay or clayey silty fine-grained sand. This has a much lower compressive strength than the gravels, but it is usually less than 1m thick. In the alluvial deposits a considerable thickness (up to 5m) of weak soils can occur including peat and highly organic silts and clays.

The sands of the Bournemouth Formation are poorly graded (Figs 12 to 15); where undisturbed they are compact. Thus they can have a high compressive strength, but the presence of laminated clays, particularly at the top of the Branksome Sand, can detract from this. The lenticular nature of these clays could cause problems of differential settlement. The in situ strength of the clays is related to their natural moisture contents which in turn related to the presence of absence of a water-table in the overlying sands. Examples of compressive strengths derived from triaxial tests on clays in the Branksome

Cell Pressure kN/m^2	Failure strain %	Moisture Content %	Bulk Density Kg/m^3	Compressive Strength Kn/n^2	Cohesion KN^c/m^2	Ø
41	8.5	20.6		116		
83	11			127		
69	8	21.0	2020	156	26	20°
128	11			176		
104	13	21.5		180		
35	5.5	20.2		129		
69	8.5			153		
69	6	19.1	2050	164	38	16°
104	5.5	18.2		181		
208	9			202		
69	11	23.6		174		
104	14	23.8	2010	180	89	N.D.
138	11	23.8		180		
69	7	23.2		208		
138	-			-		
104	8	20.5	2050	236	40	21°
207	12			252		
138	6	20.8		286		
276	12			292		
35	5	15.6		231		
69	6	14.8	2120	535	228	N.D.
104	5	15.5		606		
69	5	16.4		337		
138	9.5			444		
104	5.5	16.5	2125	752	240	12°
207	7			810		
138	6.5	16.9		696		
276	7			764		
69	5.5	19.1		404		
138	8.5			476		
104	6.5	19.2	2075	472	75	30°
207	9			545		
138	14	18.3		545		
276	18			716		
69	4	15.2		456		
138	5.5			474		
104	5	13.0	2135	592	55	38°
138	5.5	15.5		680		
69	6.5	15.9		558		
138	9			642		
104	6.5	15.6	2150	578	150	22°
207	8.5			605		
138	6.5	15.3		650		
276	11			850		
69	4	15.5		830		
104	5	15.7	2135	810	383	N.D.
138	15	15.3		660		
69	6.5	15.3		840		
104	5.5	15.1	2160	620	375	N.D.
138	6.5	15.3		790		
69	4	18.2		900		
104	6.5	18.4	2105	896	413	N.D.
145	5	17.7		684		

Table 2. Engineering parameters for twelve samples of clays from the Branksome Sand

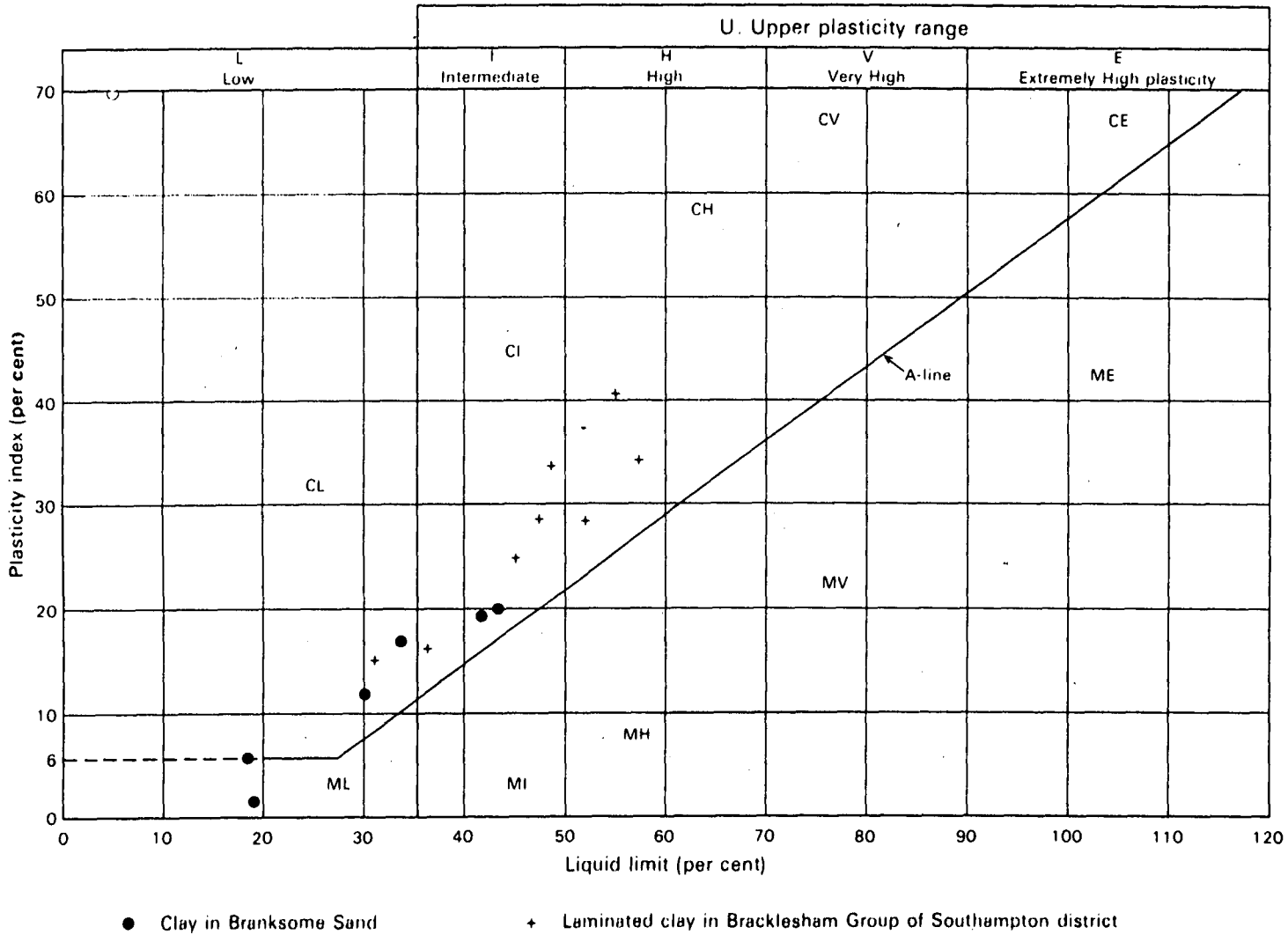


Fig. 16 Plasticity chart for clays within the Branksome Sand. Some laminated clays from the adjacent Southampton area are shown for comparison.

90-92

(figs 17-19 folded in endpocket)

Sand are shown in Table 1. The clays plot on a plasticity chart (Fig.16) in the low plasticity field not far above the A-line; similar clays from the Southampton area are shown for comparison. The amount and continuity of the fine-grained sand laminae in the clays is a major controlling factor in their moisture contents. The ability of the clays to absorb water from these sand bands and laminae could be important in excavations made in wet conditions, because it can result in a serious loss of strength. Slopes of up to 50° can be stable in well-drained sands but where a layer of clay or clayey silt occurs, even one a few centimetres thick, the generation of a perched water table renders slopes >25° unstable. This is particularly true where the clay is in the lower part of the slope. Fig.17 indicates the areas where a combination of steep slopes and the presence of clays makes instability more likely. Within the weathered zone, marcasite (iron sulphide) concretions in the Branksome Sand can give rise locally to high sulphate concentrations in the groundwater. The worked out areas of brick clay and gravel within the district are now mostly backfilled, in many cases with material of unknown origin. This is particularly true of areas that were filled in 19th and early part of 20th centuries. Fig. 18 shows the main areas of Made Ground with an estimate of its nature where possible.

HYDROGEOLOGY

The most important aquifer in the district is the Bournemouth Formation which can yield useful supplies. Groundwater has also been obtained from some of the River Terrace Deposits, but the remainder of the formations within the district have little hydrogeological significance.

Chalk is present beneath the district at depths of about 160 to >300 m below Ordnance Datum. A deep borehole drilled for water at Christchurch [1545 93843] in 1905, penetrated Chalk from 251m to 281m depth, but little water was apparently obtained. Interestingly, an unusually high yield of more than 30 l/sec was taken from seams of lignite in the Bournemouth Formation at a depth of some 60 m, but the water was so rich in iron that the borehole had to be closed off, and was subsequently abandoned.

The Reading Beds beneath the district comprise clays and sandy clays, and do not constitute an aquifer. The London Clay contains a few sandy horizons from which very small supplies of indifferent quality water might be obtained.

A study of well yields in the Bournemouth Formation aquifer over the whole of the Hampshire Basin has shown that yields in the Bournemouth - Christchurch area seem to be rather less than in elsewhere in the basin. Table 3 shows the yields that might be expected from the Bournemouth Foundation in the present district.

Table 3.

Expectancy of yields (in l/sec) from the Bournemouth Formation that would be exceeded in the given percentage of cases. It is assumed that 30m of screen are present in the saturated aquifer, and that the drawdown is 5m.

Borehole diameter (mm)	Percentage of cases		
	75%	50%	25%
150	3.7	6.4	11.3
300	5.1	8.9	15.9
450	6.2	10.9	19.3

In general within the Hampshire Basin, borehole yields do not appear to increase significantly at depths greater than about 60 m beneath the potentiometric surface. There is insufficient information in the present district with which to construct contours of the potentiometric surface. In general, levels have not been recorded more than 10m above Ordnance Datum; they are near to sea level close to the coast, and rising gently inland.

Boreholes in the Bouremouth Formation have sometimes failed due to the ingress of 'running' sand and, occasionally, to collapse. Sand screens and filter packs and the subsequent proper development of the completed borehole are therefore essential to ensure a long service life.

The groundwater quality is usually fairly good with total dissolved solids mostly <250 mg/l. The total hardness (as $CaCO_3$) is generally <100 mg/l and is not known to exceed 200

mg/l, while the chloride-ion concentration is normally <40 mg/l. Iron, however, is often present in concentrations of >1.0 mg/l, and may be sufficiently high to cause water-treatment problems.

In areas adjacent to the coast, prolonged pumping may lead to seawater intrusion, and the siting of boreholes less than 500 m from the shore is not recommended.

The Barton Clay forms an aquiclude and does not yield useful supplies of groundwater. The Chama Sand, the Becton Sand and the Headon Formation are present only in the extreme north-east corner of the district. Small supplies (probably <0.5 l/sec) might be obtained from the Chama and Becton sands, but the grain-size tends to be very fine, and it would be difficult to install satisfactory sand screens in boreholes.

Supplies of >10 l/sec have been obtained from the thicker River Terrace Deposits, but only where these extend below Ordnance Datum. Terraces at higher levels tend to drain rapidly and thus have low storage capacities.

Boreholes are not generally employed to abstract groundwater from the gravels, and large (up to 3m) diameter shafts or tube-wells are preferred. The groundwater quality can be good, but with the water table close to the ground surface, the supplies are vulnerable to pollution from surface sources. Where abstraction sites are located near to water courses, there is a possibility of induced recharge and the groundwater quality may then reflect the surface-water quality.

The alluvium of the district generally has a high clay content and yields little water. Its hydrogeological significance lies in its ability to limit the infiltration of river water into the underlying deposits.

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APPENDIX 1

CHRISTCHURCH BOREHOLE SZ 29 SW/12 [SZ2022 9301]
Highcliffe, Christchurch. Stratigraphical boreholes drilled by

Drillsure Ltd for Institute of Geological Sciences 1980-81.

Surface Level about 18m above O.D. Geologists' Log

	Thickness (m)	Depth (m)
Quaternary		
River Terrace Deposits		
Clayey sandy flint gravel	2.50	2.50
Eocene		
Barton Formation		
Barton Clay Member		
Clay, extremely sandy, greyish green, bioturbated glauconitic and clayey silty fine-grained sand, with ironstone concretions around 5 m depth. A bed of rounded flint pebbles up to 40 mm in diameter occurs at the base	7.70	10.20
Bournemouth Formation		
Boscombe Sand		
The exposed Friars Cliff section comprises three coarsening-upwards sequences. "These coarsen from intensely bioturbated dark brown, sandy silty clay with abundant plant debris, through silty sand into clean white, faintly laminated sand, erosively overlain by clean cross-bedded fine to medium sand. Ophiomorpha is common in the upper sandy part of each cycle ... "(Plint, 1980, p.96). The topmost 2 to 3m contain 'ball and pillow' soft-sediment deformation structures. Cored between 16.20 and 20.45 m.	10.25	20.45
No core. Geophysical logs indicate clay-free sand with few more clay-rich beds and lignitic seams	9.78	30.23
Branksome sand		
Sand, clay-free, fine- to medium-grained, olive grey to brownish olive grey with a sharp base. The sand becomes medium- to coarse-grained from 53.30 to 54.70m and from 59.20 to 59.40m. Clay clasts occur at several horizons. Cross-bedded between 53.30 and 54.50m. Units of		

laminated olive grey and yellowish brown clay with partings and interbeds of fine to very fine-grained sand occur at intervals: 30.23 to 30.90m, 33.41 to 33.82m, 35.19 to 38.86m, 41.29 to 41.54m, 43.30 to 43.62m, and 45.10 to 45.65m. Lignitic laminae are common in sand beds; solid lignite with associated seatearth and rootlets occurs from 43.15 to 43.30m.	30.17	60.50
Clay, brownish olive grey, with silt partings, and burrows	0.74	61.24
Sand, medium-grained, olive grey to brownish olive grey, becoming coarse-grained at around 71m. Grain size varies between medium and very coarse below this. Sharp base. Cross bedded at intervals, 79.40 to 79.50m, 79.77 to 80.10m, and around 81.50m. Lignitic debris is common as bedding laminae. Clay bands and laminae are common between 66.60 and 67.10m and between 88.50 and 89.70m. Disrupted clay bands are common between 93.10 and 93.90m.	34.25	95.49
Clay, silty, yellowish brown with partings, lenses and bands of coarse-grained silt to fine-grained sand. Below 96.10m there is a gradational change to dark yellowish brown medium-grained sand with many irregular and disrupted clay bands. The sands become coarse-grained at 103.70m. Pale grey rotted flint pebbles occur at 98.10m. The unit, which overall fines upwards, has a sharp base.	8.86	104.35
Clay, silty, dark yellowish brown with impersistent silt partings and lenses. Sharp base	6.25	110.60
Sand, medium-to coarse-grained, brownish olive grey, gravelly at 136.0m, and with bands of lignitic debris common. Very poorly sorted, extremely clayey fine-grained sand with irregular clay seams and pods and fragmental lignite between 120.55 and 121.12m. Yellowish brown silty clay with pods and lenses of fine- to coarse-grained sand from 134.92 to 135.40m	25.50	136.10
Sand, coarse- to very coarse-grained clean, brownish olive grey, sparsely		

lignitic becoming very coarse-grained at 143m. Dark yellowish brown, very silty, clay with some lignitic debris between 138.45 and 138.57m. Sharp base.	7.20	143.30
Sand, fine- to medium-grained, coarse-grained from 154.30 to 155.60m, commonly cross bedded and with bands of lignitic debris, brownish olive grey. Disrupted clay laminae and clay clasts from 147.60 to 147.90m. Yellowish brown clay with sand laminae from 147.95 to 148.10m. Extremely lignitic dusky brown clay from 151.73 to 152.0m. From 158.60m to a sharp base at 158.8m, dark yellowish brown very fine-grained clayey sand	15.50	158.80
Clay, sand-free, brownish olive grey with clasts of brown clay and pods of fine-grained sand. Massive fine-grained lignite from 159.34 to 159.57m, with rootlets at 150.60m. Fine-grained silt laminae from 159.70 to 159.93m.	1.24	160.04
Well defined fining-upwards unit capped by lignite (160.04 to 160.30m), with associated rootlets between base of lignite and 163.0m, in seatearth-type clays. At about 160.7m the clay is yellowish brown becoming yellowish grey below 161.0m and pale olive grey below 161.7m. Below 162.5m the clay becomes slightly silty. Siderite spherules occur between 163.40 and 164.38m. The clay becomes silty by 164.8m and passes gradationally to clayey silt by 165.03m	4.99	165.03
Silt, clayey, pale yellowish brown, and cross-laminated, fine-grained sand, passing down into olive grey silty clay with laminae of coarse-grained silt. Rootlets between 166.00 and 167.46m. Siderite-cemented siltstones at the base	2.43	167.46
Clay, silty, olive grey roughly banded with some silt laminae which becomes very common below 169.10m. Some bands of olive grey medium-grained sand occur in the lowest part, with clay clasts and olive grey clay laminae	2.67	170.13

Sand, medium- to coarse-grained clean, olive grey, very coarse-grained between 183.00 and 185.00m. Abundant clay clasts from 187.70 to 189.30 m. Lignite debris common from 174.30 to 176.10m. Band of flint pebbles from 181.10 to 181.18m. Highly distrubed and burrowed clay from 181.96 to 182.42 m.	20.87	191.00
London Clay Formation		
Christchurch Member		
Clay, silty, colour-banded yellowish brown with some silt partings; a little lignite debris, and traces of fine-grained mica. Bedding dips up to 35°	3.30	194.30
Sand, fine-grained, moderately clayey, greenish grey, slightly glauconitic, and micaeous.	1.57	195.87
Clay, silty, dark yellowish brown, with laminae of olive grey, coarse-grained silt	1.68	197.55
Sand, fine-grained, rather clayey slightly micaceous and glauconitic, becoming medium grained at the base	3.89	201.44
Sand, clayey fine- to very fine-grained olive grey, diffusely interbedded with silty clay, and with occasional bands of medium-grained sand. Pale grey very clayey silt with rootlets and burrows from 201. 44 to 202.00m.	7.21	208.65
Sand, medium- to fine-grained, olive grey with several horizons containing clay clasts and some clay bands with laminae of fine-grained sand. From 221.55 to 224.65m colour-banded olive grey laminated silty clay with slightly micaceous clayey silt and some yellowish brown fine-grained sand. Rootlets at 224.05m. From 229.24 to 229.53m olive grey silty clay with some partings of fine-grained sand. Sharp base	22.85	231.50
Unnamed Member		
Clay, silty olive grey and brownish olive grey-burrowed, poorly banded or laminated and clayey silt, with some claystones. From 237.76 to 237.96m olive grey slightly micaeous, fine- to very		

fine-grained sand. From 238.97 to 239.12m brownish olive grey medium- to coarse-grained poorly laminated sand. From 239.51 to 240.38m pale yellowish olive grey, very fine-grained sand with scattered glauconite. From 243.46 to 243.62m pale olive grey fine-grained sand with scattered glauconite	12.12	243.62
Flint gravel with flints up to 100mm across	00.23	243.85
Coarsening-upwards cycle comprising greenish grey very fine-grained sand with scattered glauconite and mica, becoming clayier with depth. From 247.28 to 247.40m, olive grey mudstone and laminated yellowish brown clay. Claystone from 245.27 to 245.36m	3.55	247.40
Well defined coarsening upwards cycle; uppermost part is greenish grey, glauconitic, fine-grained sand, the clay content rising steadily below 251m, with increasing bioturbation. Below 254m is olive grey extremely silty sandy clay. Shelly material, mainly bivalves, below 257.60m. Claystones at 258.25m and from 259.50m. Sharp base	13.72	261.12
Coarsening-upwards cycle, comprising at the top olive grey, very clayey, silt with scattered glauconite, passing down to olive grey, bioturbated, glauconitic, extremely silty clay at around 262.20m. Shelly material common, mainly bivalves and gastropods. Claystone from 261.23 to 261.38m.	13.18	274.30
(274.30m bottom of cored part of the borehole. The following descriptions are based on geophysical logs and rate of penetration while rock-bitting. There was virtually no return of cuttings in the drilling mud). Silty to extremely silty clay, possibly with a clayey silt section between 282.20 and 285.80m. Thinner bands of rather less clayey silt or sand may occur between 279.60 and 280.00m, between 287.00 and 287.20m, and between 295.80 and 296.40m. Claystones from 278.70 to 278.85m and from 287.00 to 287.20m	24.30	298.60

Palaeocene		
Reading Formation		
Clay, red-mottled grey, varying in silt and sand content. The least sandy or silty sections probably occur between 298.60 and 299.40m and between 305.20 and 307.80m.	19.95	318.55

Borehole SZ 19 SE/9. [1544 9380] Knapp Mill, Christchurch.
Disused water borehole drilled for West Hants. Water Co.
Surface level +6.1m OD. Driller's log.

	Thickness	Depth
Made Ground	1.52	1.52
River Terrace Deposits		
Ballast gravel	5.18	6.70
Sand, red running	1.83	8.53
Sand and ballast gravel, grey	0.92	9.45
Bournemouth Formation		
Branksome Sand Member		
Clay, sandy	1.22	10.67
Sand, grey running	4.27	14.94
Clay, sandy	0.91	15.85
Sand, running and layers of clay	8.53	24.38
Sand, grey running and lignite	5.49	29.87
Clay, sandy	3.05	32.92
Sand, fine running	11.89	44.81
Clay and peat	0.61	45.42
Sand, running and lignite	15.54	60.96
Clay, sandy	1.52	62.48
Sand, running and lignite	0.61	63.09
Sandstone, soft	0.92	64.01
Sand, running and lignite	2.13	66.14
Clay, sandy	1.22	67.36
Sand, running, lignite and sandstone	2.44	69.80
Clay, hard, dry sandy (?and sandstone)	3.35	73.15
Sand, running, layers of lignite and sandstone	11.50	84.73
Clay, soft, sandy, (?and stone)	4.48	89.21
Clay, hard, sandy,	2.84	92.05
Sand, running, layers of clay, stone and lignite	3.05	95.10
Clay, layers of coarse sand and sandstone	8.53	103.63
Sand, running and lignite	3.66	107.29
Clay, mottled, sandy	2.44	109.73
Sand, running and lignite	6.40	116.13
Clay, sandy	3.05	119.18
Sand, running and lignite	3.04	122.32

London Clay Formation

Christchurch Sand Member

Clay, sandy	3.87	126.19
Hard rock	0.91	127.10
Clay, sandy stone and lignite	1.83	128.93
Clay, sandy	2.13	131.06
Clay, sandy and stone	2.44	133.50
Sand, loamy	3.66	137.16
Sand, fine running and lignite	9.75	146.91
Clay, sandy	2.14	149.09
Clay, hard brown	6.09	155.14
Sand, fine running and lignite	8.23	163.37
Clay, soft, sandy	3.35	166.72
Sand, running clay and pebbles	4.12	170.84
Hard rock	0.46	171.30
Sand, loamy	11.27	182.57
Unnamed Member		
Clay, claystones, shells and pebbles	34.14	216.71
Clay, green sandy	4.57	221.28

Reading Formation

Clay, red mottled	0.92	222.20
Sandstone, soft	1.22	223.42
Clay, sandy mottled, with claystones	14.93	238.35
Sand	6.40	244.75
Clay, sandy	6.40	251.15

Upper Chalk

Chalk and layers of sand	29.57	280.72

Borehole SZ 19 NW/57 [SZ 1320 9519]. Holdenhurst Sewerage Works. Borehole designed for use in sewerage treatment. Drilled by Foundation Engineering Ltd for Wessex Water Authority.

Surface level + 5.25m O.D. Geologists' Log

	Thickness (m)	Depth (m)
Bournemouth Formation		
Branksome Sand		
Sand, very fine- to fine-grained, greyish brown, clayey with greyish brown laminated carbonaceous material common, some marcasite	3.15	13.15
Clay, silty, greyish brown, seatearth texture	1.60	14.75

Clay, greyish brown to brown, silty colour banding based on carbonaceous content. Dip 5°. Some zones of very silty clay with marcasite and lignite, including fine lignitic debris. Some silt partings with plant fragments; suggestion of varved clay in places	3.48	18.43
Clay, silty, becoming very silty in depth, variable lamination and colour banding, buff to greyish brown with brown bands. Some lignitic laminae notably around 18.90m. Thin very fine-grained sand layers at 21.37 to 21.42m and 21.62 to 21.67m. Some marcasite.	3.66	21.89
Silt to very fine-grained sand, very clayey, greyish brown, laminated, fine lignitic debris	0.11	22.00
Clay, silty, dark greyish brown to brown, colour-banded and laminated with partings of very fine-grained sand to silt, occasionally up to 10 mm thick.	0.65	22.65
Sand to silt, brown to brownish grey laminated, occasional thin clays, finely lignitic	1.62	24.27
Sand, very fine-grained slightly lignitic.	0.10	24.37
Lignite, with marcasite (Core loss)	1.52	25.89
Sludge from barrel	1.52	27.41
Sand, medium-grained, grey, sharp base.	0.33	27.74
Core loss	2.74	30.45
Sand, grey, coarse-grained. Possible clay clasts. Much core loss.	3.04	33.49
Core loss.	1.52	35.01
Clay, very silty, rooty, plant stems.	1.53	36.52
Sand, medium- to fine-grained, some lignitic debris.	0.62	37.15
Clay, greyish brown, extremely silty, colour banded and laminated.	2.42	39.57
Sand, brownish grey, medium-grained, somewhat clayey, lignitic.	0.45	40.02
Sand, brownish grey, medium-grained, brown and lignitic at 41.30m and 42.40 to 42.80m. Dark silty clay band with possible sphaerosiderite from 43.40 to 43.50m. Very lignitic 43.70m to base.	4.01	44.03
Sand, medium-grained, fawn to dark brown or dark brown, very lignitic. Sharp base.	1.27	45.30
Clay, dark greyish brown to brown roughly colour-banded, some fine-grained sand to silt partings. Some marcasite and		

lignite. Silty laminae common below 45.90 down to 46.30m.	1.60	46.90
Lignite, solid, black.	0.20	47.10
Silt to very fine-grained sand, (Seatearth), very clayey, pale brown, abundant rootlets in well developed network	1.50	48.60
Silt, to very fine-grained sand, laminated and interbedded with silty clay, fine lignite, some rootlets, burrows	0.80	49.40
Clay, brownish grey, very silty, banded with clayey silt. Fine lignitic debris, marcasite, burrows.	0.30	49.70
Ironstone, clayey, silty.	0.20	49.90
Silt to very fine-grained sand, grey to greyish brown, poorly laminated, some fine lignitic debris. Finely micaceous.	1.08	50.98
Clay, greyish brown, extremely silty, interbanded with very fine-grained sand and silt in units up to 15mm thick. Passing down and becoming silt dominant in lowest 0.05m	2.72	52.70
Ironstone	0.20	52.90
Clay, extremely sandy and silty, greyish brown with silt partings and thin bands. Dip of 5° to 10°	2.37	55.27
Clay, greyish brown, silty, well laminated with thin very fine-grained sand to silt layers. Sharp base.	0.74	56.04
Clay, pale buff grey, silty, mainly structureless, listric surfaces, silt content increasing downwards.	1.35	57.39
Clay, brownish grey with very fine-grained sand and silt. Abundant plant debris rather structureless	0.86	58.25
Clay, brownish grey, roughly laminated.	0.66	58.91
Sand, greyish brown, fine-grained clayey, some carbonaceous debris, clay clasts.	1.52	60.43
Core missing	4.56	64.99
Silt, brownish grey, clayey, laminated	1.52	66.51
Core missing	1.25	67.76
Clay, silty, buff and orange, thin silt partings. Dip 18° approximately. Lamination poorly developed between 69.00 and 69.28m, also more silty. Sharp base, rubbly with lateritic material in basal 0.1m	1.94	69.70
Clay, dark greyish brown, with pale lamination, disrupted by rootlets.	0.50	70.20
Clay, dark greyish brown, silty, with listric surfaces and rootlets	0.39	70.59
Clay, greyish brown, silty, very poorly laminated, some fine silt		

partings. Occasional listric surfaces. Some fine lignitic debris, particularly below 71.60m with rootlets, where lamination dies out. Dark carbonaceous rooty with plant debris below 71.60m. Possible sub-vertical burrows with dished lignitic laminae up to 1cm wide	3.22	73.81
Clay (Seatearth), greyish brown, silty, flecks of lignite, listric surfaces, rootlets. Hard siderite-cemented ironstone 0.08m thick at 76.17m	4.03	77.84
Clay, dark greyish brown, roughly laminated, abundant large plant debris, dip up to 10°. Occasional listric surfaces.	2.16	80.00
Clay, extremely silty, greyish brown, sand-filled sub-horizontal burrows. Confused bedding. Some sub-vertical clay- filled burrows	0.50	80.50
Sand, very fine-grained to silt, very clayey, with wispy paler laminae, medium grey.	2.40	82.90
Clay, silty, with many thin silt wisps and laminae	0.13	83.03
Sand, very clayey, ill-sorted, lignitic debris, structureless.	0.52	83.55
Core missing.	4.62	88.17
Clay, dark brownish grey, very silty, abundant pale silt wisps, laminae, and pods. Sand-filled burrows subparallel to bedding and subvertical.	1.83	90.00

Bottom of borehole

Hengistbury Head Section 1 [SZ 1687 9067]
Measured by E C Freshney and R A Edwards 1980

BARTON CLAY	Thickness (m)
Sand, very clayey, dark green (brighter green than beds below)	1.50
Sand, clayey, dark green	0.70
Pebble bed of scattered rounded, black flints.	
Sand, very clayey, green to greenish brown and purplish brown	1.30
Pebble bed of scattered, rounded, black flints.	
Sand, very clayey green to greenish brown and purplish brown	0.60

BOURNEMOUTH FORMATION

Boscombe Sand Member

Pebble and cobble bed of rounded black flints; some patchy ferruginous cementation.	0.25
Sand, fine- to medium-grained, pale yellow to buff with some ferruginous staining	1.00
Pebble bed of rounded black flints	
Sand, medium- to coarse-grained, pale yellow to buff with some ferruginous staining	0.50
Sand, medium-grained, buff with some traces of ferruginous staining, passes imperceptibly down into	0.30
Sand, medium-grained, light purplish to greyish brown, with some ferruginous staining; irregularly banded pale sand layers in lower part	1.00
Clay	0.01 to 0.02
Sand, medium-grained, light brown to buff, ferruginous stained	0.90
Clay horizon (rippled between sections 1 and 8)	
Sand, coarse-grained with small pale flint grains; ferruginous stained in upper 0.5m	0.80
Sand, coarse-grained light chocolate brown, cross-bedded with fine pebbles in the foresets; thin band of lignitic fragments	0.50
Sand, brown, finely laminated, burrowed	0.45
Sand, chocolate brown	0.45
Clay, slightly sandy, stiff, brown with ferruginous iron staining	0.05
Sand, buff and organic, red-brown laminated sand; organic brown layers somewhat clayey; pebble bed 0.3m above base	0.40
Sand, pale buff, with pebble layers and lens, pebbles up to 10mm.	0.30 seen
Total section	10.8m

Hengistbury Head Section 2a [SZ 1689 9066] and 2b [SZ 1692 9065]
Measured by E C Freshney and R A Edwards 1980 and C R Bristow
in June 1983 (uppermost 4m).

(Section 2a)

	Thickness (m)
MADE GROUND	
Gravel and sand, unbedded; dies out eastwards	0 - 0.60
?RIVER TERRACE DEPOSITS	
Sand, gravelley	1.00
BARTON CLAY	
Sand, fine-grained, thinly bedded	2.00
Clay, sandy, dark grey, laminated	0.30
Sand, clayey, green to greenish brown; scattered pebbles 0.5m above base	2.00
Cobble bed, maximum cobble size 190mm, chatter marked	0.16
BOURNEMOUTH FORMATION	
Boscombe Sand Member	
Sand, medium-grained, buff to yellow	0.50
Pebble bed; pebbles up to 3 cm	
Sand, medium-grained, buff to yellow	0.60
Cobble bed; maximum cobble size 195mm	0.20 - 0.30

(Section 2b)

Sand, clayey, organic, dark purplish brown to black; thickens eastwards over 10m distance to 1m	0.20 - 1.00
Sand, clayey, mottled medium to pale purplish brown, massive; zone of clay clasts 1.2m above base = "Slurry bed"	2.50
Sand, medium-grained, slightly clayey, mottled light fawn, with clasts of black sand	0.50
Sand, medium-grained, fawn, hard and soft banding; vertical burrows	0.90
Sand, medium-grained, ferruginous, yellowish brown; ?cross bedding in upper 0.3m.	0.65
Sand, medium-grained, somewhat clayey, purplish brown to organic brown; at top clasts of dark brown to black sand and scattered flint pebbles and cobbles	0.20 seen
Total section	c 14.20m

Hengistbury Head Section 3 [SZ 1700 9063]
Measured by E C Freshney and R A Edwards 1980.

BARTON CLAY	
Sand, clayey, green to greenish brown, scattered pebbles 0.5m above base	1.00
Cobble bed; maximum cobble size 170mm	0.10
BOURNEMOUTH FORMATION	
Boscombe Sand Member	
Sand, medium-grained, greyish fawn to fawn	0.85
Sand, medium-grained, chocolate-brown to reddish brown	0.15
Cobble bed; cobbles up to 140mm; one clast of black sand	0 - 0.15
Sand, clayey, dark chocolate-brown thins eastwards to 0m (possible final eastward remnant of "slurry bed")	0 - 0.20
Sand, medium-grained, dark chocolate brown to black with top 0.2m composed of pockets and lenses of light brown sand and clayey sand above base)	0.90
Sand, medium-grained, slightly clayey, chocolate to purplish brown, with clasts of darker brown sand; some Pholas burrows; dark brown sand layers 0.8 and 0.9m from base	2.10
Sand, medium-grained, with pebble bed at top; pale grey with brown sand layers; abundant burrows	0.41
Sand, medium-grained, very pale grey	0.55 seen
Total section	6.35

Hengistbury Head Section 4 [SZ 1705 9062]
Measured by E C Freshney and R A Edwards in 1980, and
C R Bristow (beds above the Bournemouth Formation in June 1983

	Thickness (m)
RIVER TERRACE DEPOSITS (Tenth)	
Gravel, sandy	0.60
BARTON CLAY (FORMATION)	
Warren Hill Sand (Member)	
Sand, fine-grained, orange, laminated	1.50
Sand, as above, unbedded	4.50
Sandstone, ferruginously cemented	0.01 to 0.02
BARTON CLAY (UNNAMED MEMBER)	
Sand, clayey, greyish buff, laminated	3.00
Sideritic nodule bed max.	0.15
Clay, sandy, greenish grey	0.80

Clay, sandy, laminated, dark grey	0.80
Sand, fine-grained, very clayey, dark greyish green	2.00
Pebble bed, well rounded black flints mostly small (up to 3 cm), but some cobbles (up to 12 cm)	0.05 - 0.10
BOURNEMOUTH FORMATION	
Boscombe Sand Member	
Sand, medium-grained, grey with persistent lenticles of sand and clay	0.30
Sand and clay, laminated, chocolate brown	0.03
Sand, medium-grained, brown and grey, ripple drifted, poorly laminated at top	0.20
Sand and clay, laminated, chocolate brown	0.03
Sand, medium-grained, grey to greyish brown, laminated and cross-bedded	0.20
Pebble bed, with pebbles up to 3cm, merges westward with cobble bed below	0.02 - 0.03
Sand, medium-grained, grey to greyish brown	0.20
Cobble bed, maximum cobble size 18cm, with 10-cm cobbles common	0.10
Sand, coarse-grained, grey to greyish brown	0.12
Sand, medium-to coarse-grained	0.03
Sand, medium-grained, pale brown, banded with basal 5 cm containing up to 2-cm clasts of black sand	0.15
Sand, black to dark brown; lignitic layer near top	1.60 seen
Total section	c20.50 m

Hengistbury Head Section 5 [SZ 1714 9059]
Measured by E C Freshney and R A Edwards in 1980

	Thickness (m)
BARTON CLAY	
Sand, clayey, greenish brown, glauconitic; pebbly layer 0.25m above base	0.60
BOURNEMOUTH FORMATION	
Boscombe Sand Member	
Sand, medium-grained, grey to greyish fawn with persistent lignitic layers or fragments	1.00
Sand, clayey, lignitic, brown	0.04
Sand, medium-grained, grey to pale fawn with pellets of chocolate brown clay and some lignitic debris	0.30
Cobble bed; cobbles mostly between 60 and 75m	0.10
Sand, medium-grained, grey to pale fawn	0.15

Pebble bed; maximum pebble size about 2cm	0.02
Sand, medium-grained, grey to pale fawn becoming more fawn downward	0.23
Sand, medium-grained, pale to medium fawn, poorly laminated	0.30
Sand, medium to dark chocolate brown; very dark towards the top, with scattered pebbles and cobbles in top 20cm; cobbles up to 12cm	0.05 - 0.20
Sand, medium-grained, coarser towards base, light brown, with lignitic material in lower part	0.18
Sand, medium brown, cross-bedded, with Pholas burrows; part of the section is in homogeneous mid-chocolate brown coloured sands that pass eastwards into mottled medium to pale brown sand with Pholas burrows	0.70
Sand, medium-grained, light fawn with impersistent brown bands	0.20 seen
Total section	3.90m

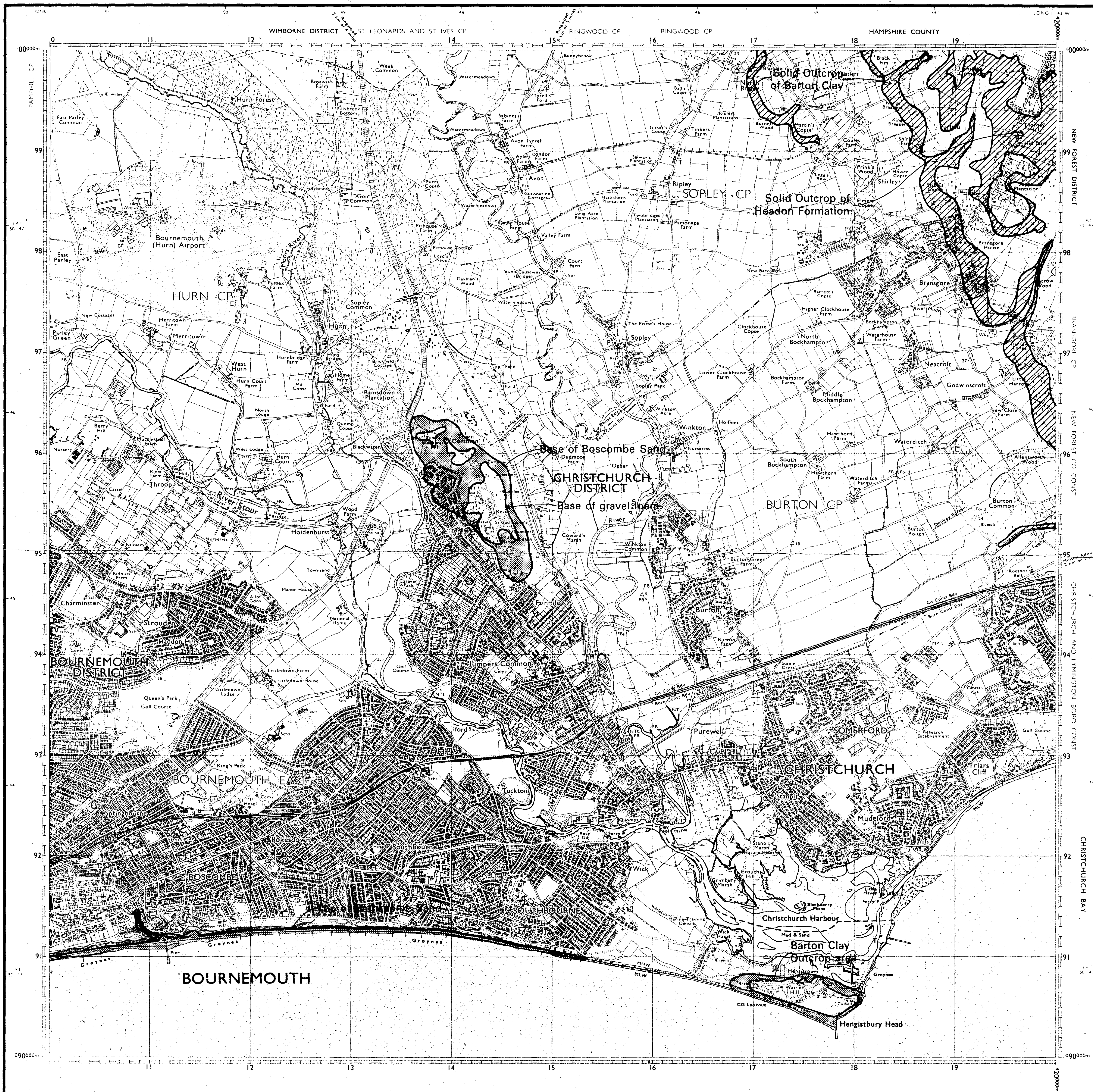
Hengistbury Head Section 6 [SZ 1721 9056]
Measured by E C Freshney and R A Edwards in 1980

	Thickness (m)
BARTON CLAY	
Sand, clayey, greenish brown, glauconitic	0.60 recorded
BOURNEMOUTH FORMATION	
Boscombe Sand Member	
Sand, medium-grained, grey to fawn with lignitic fragments; cross-laminated at the top	1.00
Sand, coarser-grained than above; hard cross-bedded coarse layer 0.25m from base; roughly laminated, medium- and coarse-grained sand in basal 25 cm	0.90
Cobble bed (an amalgamation of the beds at 1.44m, 1.61m and 2.16m from top of Bournemouth Formation in Section 5); maximum cobble size about 10cm, but most less than 5cm	0.10
Sand, medium-grained, pale brown with some burrowing and mottling	0.30
Pebble bed, scattered layer at top of bed below	0.03
Sand, medium-grained	0.30
Cobble bed; cobbles up to 8cm with some fragments of black sand	0.03

Sand, medium-grained, dark chocolate brown with Pholas burrows	0.30 seen
Total section	3.50m

Hengistbury Head Section 7 [1723 9055]
Measured by E C Freshney and R A Edwards in 1980

	Thickness (m)
BARTON CLAY	
Sand, clayey, greenish brown, glauconitic	0.60 recorded
BOURNEMOUTH FORMATION	
Boscombe Sand Member	
Sand, medium-grained, grey to pale fawn, cross-bedded at top	0.50
Clay, dark brown	0.01 to 0.02
Sand, medium-grained, medium grey to pale fawn with lignitic fragments	0.50
Pebble bed; maximum pebble size 6cm	0.10
Sand, fine- to medium-grained, grey to pale fawn, slightly ferruginous stained with some Pholas burrows	0.40
Pebble bed with small (<4cm) pebbles	
Sand, pale fawn, heavily mottled with burrows; poorly laminated in bottom 20 cm	0.90
Sand, dark chocolate brown - the colour has a very irregular top which is probably not an eroded junction.	0.20 seen.
Total section	3.20m.



Mixed sand and clay at surface in areas with slope angles greater than 25°

Mixed sand and clay at surface in areas with slope angles less than 25°

Gravel, Sand or Alluvium at surface

Fig. 17 Areas of steep slopes within mixed sand and clay sequences.

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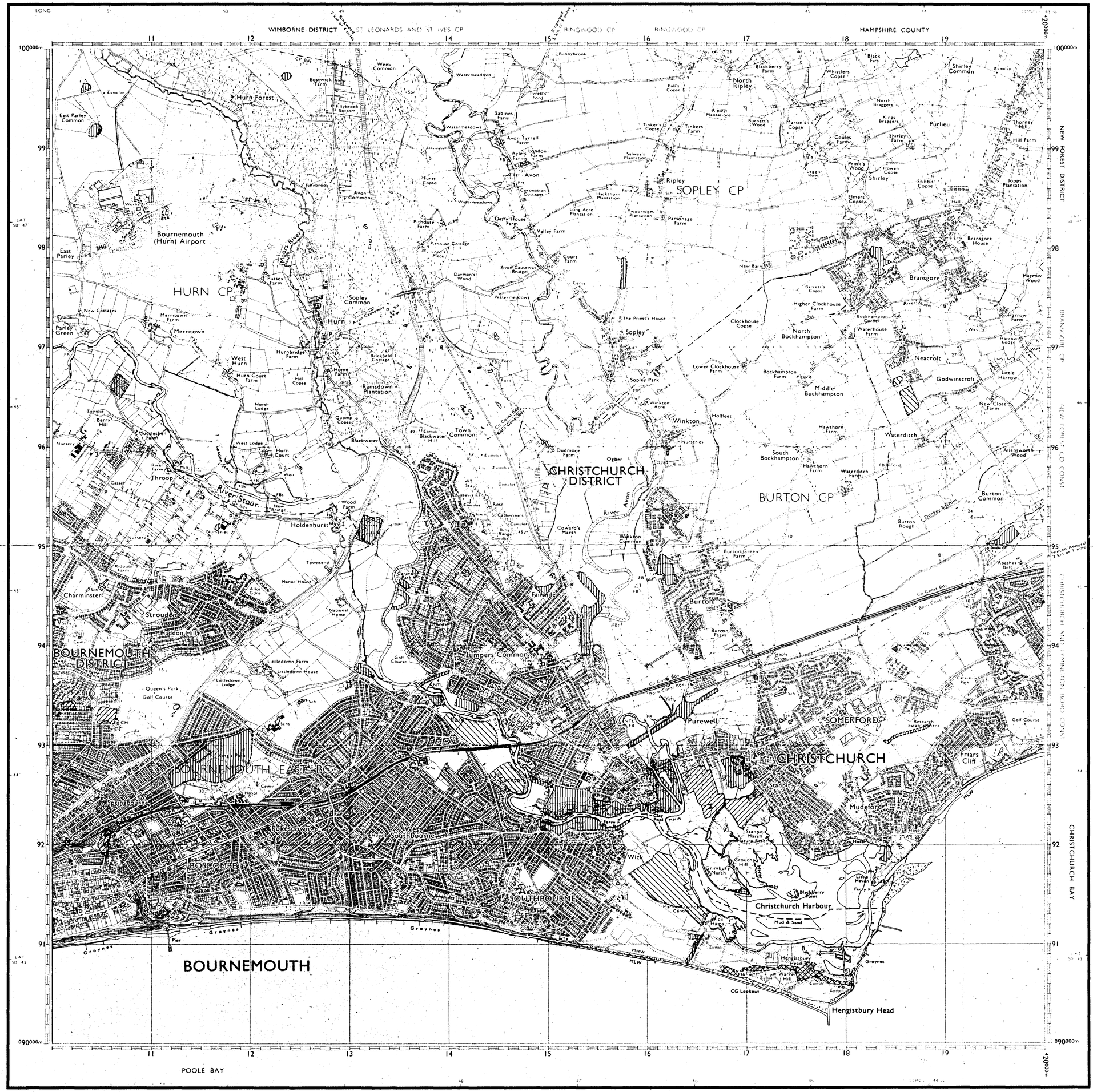

Spoil from mineral workings

Waste of unknown type

Probably mainly building rubble

Probably contains some household refuse as well as rubbish

Fig. 18 Areas of Made Ground

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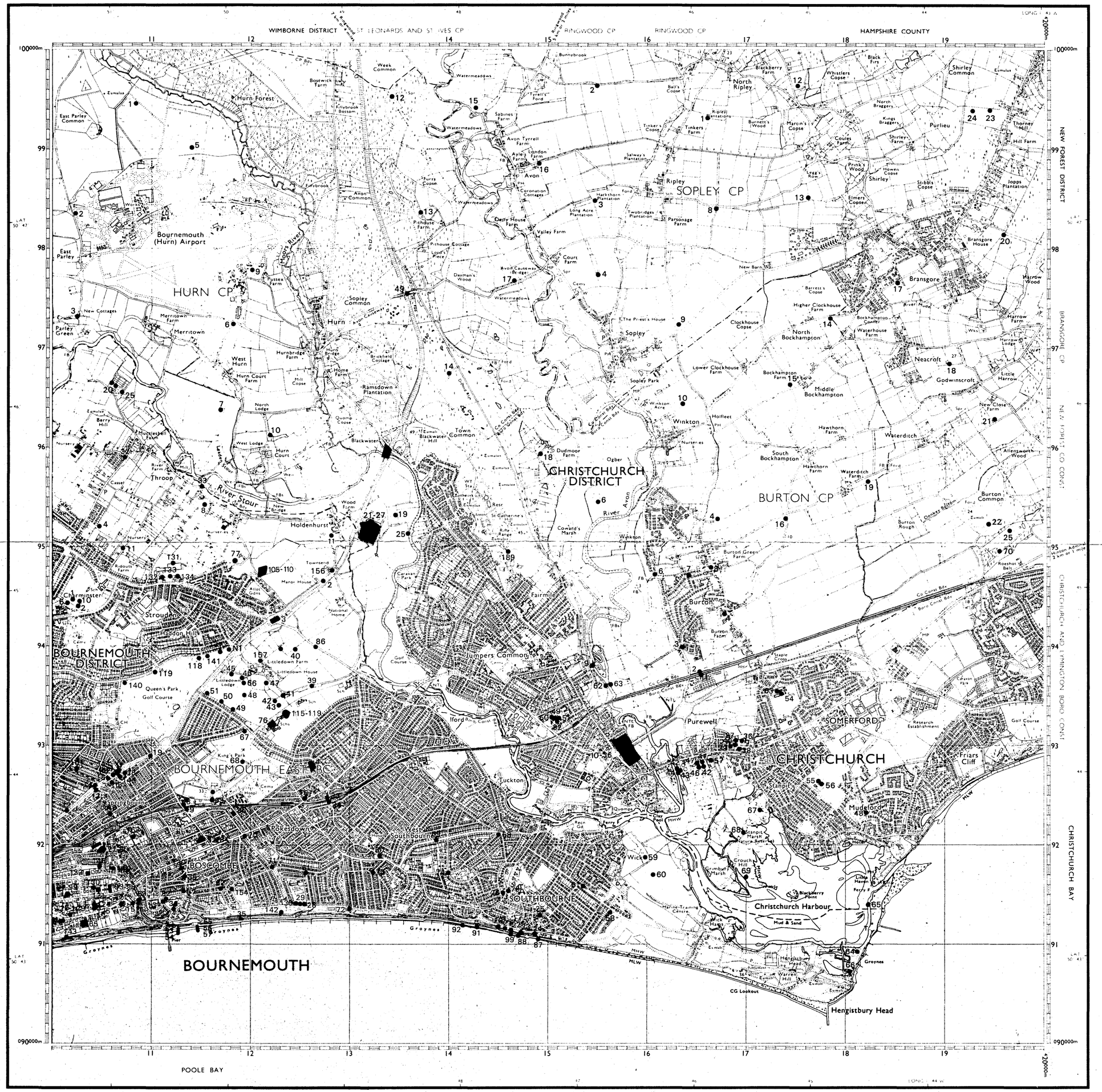

8 ● Borehole

17-25 ■ Sites with more than one borehole

Numbers are those of the BGS 1:10,000 record system and are preceded by SZ 19 NW, 19 NE, 19 SW or 19 SE depending upon which 1:10,000 map they are sited on.

Fig. 19 Borehole sites for sheet quadrants SZ 19 NW, NE, SW and SE.

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