The Lower Albian Monk's Bay Sandstone Formation (formerly the Carstone) of the Isle of Wight: its distribution, litho- and bio-stratigraphy.

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Abstract

The Monk's Bay Sandstone Formation (MBSF) is the new name for the Lower Albian ferruginous sandstone that was formerly known as the Carstone of the Isle of Wight. The new term was proposed to remove any confusion with the Carstone, of similar age and lithology, described from the separate Lower Cretaceous sedimentary basin of Eastern England. This paper formalises the nomenclatural change outlined in the Lower Cretaceous Framework Report, ratified by the Geological Society Stratigraphy Commission.

The MBSF, representing a major mid-Albian transgressive event, is described from a series of boreholes drilled by the British Geological Survey across the Isle of Wight, and from additional coastal exposures, together with reinterpretations of sections described in earlier works.

The age range of the MBSF is determined in relation to recent biostratigraphical schemes supported with new data from the previously unknown presence of foraminifera. Deposits, belonging to the *Leymeriella regularis* Subzone, were previously considered to be absent from the succession and represent the stratigraphical gap separating the formation from the underlying Sandrock Formation. However a first occurrence of tubular foraminifera resembling *Hyperammina*/'*Rhizammina* cf *dichotomata* suggest that the oldest part of the formation in the northeast of the island may be of *regularis* Subzone age. This unconformity is correlated with the sequence boundary LG4 of Hesselbo and the presence of the *Sonneratia kitchini* Subzone at the base of the MBSF on the Isle of Wight suggests that this boundary should be placed at the lower of two candidate horizons within the successions of the Weald.

The formation is restricted to the Isle of Wight but is coeval with similar coarse-grained sediments, e.g the Carstone and 'JunctionBeds' to the north. The palaeogeography of the formation and the relationship with these similar deposits and the implications for the timing of mid-Albian structural events is briefly discussed. The identification of older Lower Greensand Group sediments beneath the MBSF in boreholes north of the Isle of Wight structure, together with new survey data indicating north-south orientated faulting affecting the early Cretaceous implies a tectonic element to the distribution the Lower Greensand Group sediments. Taken together these imply a complex interaction of tectonics and transgressive events throughout the Aptian and Albian over this structural high.

Keywords: Lower Cretaceous, Isle of Wight, Lower Greensand Group, Lithostratigraphy, Biostratigraphy

1. Introduction

The Monk's Bay Sandstone Formation is a new name for the Carstone of the Isle of Wight. It was first proposed in a British Geological Survey Research report (Hopson et al., 2008) and subsequently ratified by the Stratigraphy commission of the Geological Society. The term 'Carstone' was first applied to the Isle of Wight succession by Reid and Strahan (1889), who regarded it as a correlative of the Carstone of Norfolk. Whilst the two units are of similar age and lithology they are not contiguous. The Monk's Bay Sandstone Formation consists of interbedded units of highly ferruginous, generally coarse-grained, weakly consolidated quartz-rich sandstone, fine-grained pebbly sandstone (gritstone) and ironstone that form the upper part of the Lower greensand Group of the Isle of Wight (Tab. 1). It equates to the upper part of Fitton's (1847) Group XVI.

Group	Formation	Stage
Selborne	Upper Greensand	Albian
	Gault	
Lower Greensand	Monk's Bay Sandstone	
	Sandrock	
		Aptian
	Ferruginous Sands	
	Atherfield Clay	

Table 1. Simplified litho- and chrono-stratigraphy of part of the Lower Cretaceous of the Isle of Wight.

The formation can be traced continuously beneath the base of the Gault Formation from Compton Bay, in the west, through to Red Cliff (north of Sandown) in the east and around the southern downs in the south-east of the island (Fig 1). Much of the outcrop-pattern along the northern flank of these southern downs is complicated by landslides, and a downwash of Upper Greensand and Gault debris obscures much of the Monk's Bay Sandstone outcrop. The coastal exposures at Luccombe Chine [SZ 5828 7929] and the cliffs around that area and then southward around Dunnose [SZ 5818 7829] towards Monk's Bay offer the best exposures of the formation both historically and during the recent survey.

Along the outcrop the Monk's Bay Sandstone rests with a slightly disconformable contact on the Sandrock Formation and is seen to pass gradationally upwards, over c.1.5 m), into the Gault. In this paper, the boundary between the Monk's Bay Sandstone and the Gault is placed at the horizon. This is generally marked by a distinct colour change from dark yellow brown below to dark greenish grey above. However, where the clay and silt content is disseminated, probably by bioturbation, rather than preserved in discrete laminae, then the uppermost part of the Monk's Bay Sandstone takes on a brownish green/grey colour. The Monk's Bay Sandstone usually forms a prominent feature, particularly where harder iron-cemented gritstones predominate, but is less obvious where the formation is found along the steeply dipping Brighstone and Sandown monoclines in the southwest and east, respectively, of the island. However, in both the well-featured and steeply dipping outcrops, the characteristic bright orange brown soils with ironstone clasts formed from this formation, can be readily identified in most areas.

Place Fig.1. hereabouts

The Monk's Bay Sandstone varies considerably in thickness across the Isle of Wight from a minimum of 1.1 m seen in the Compton Chine Borehole SZ38NE30 [SZ 36935 85182] to a maximum of 22.17 m at Red Cliff [SZ 6266 8553] (White, 1921, p.30) north of Sandown. Details of the most important sites are given later in this paper.

All of the sections are south of the Sandown and Brighstone monoclinal axes and demonstrate a general north-easterly thickening of the formation that is contrary to the south-easterly thickening of the other units of the Lower Greensand Group on the island. To the west of the Isle of Wight the formation is known to thin further and at Punfield in Dorset, it is represented by only a few centimetres of pebbly sandstone.

North of the monoclinal axes the Lower Greensand Group is severely attenuated in deeper boreholes (for example in the hydrocarbon boreholes of Sandhills 1 and 2 and Bouldnor Copse) of the island. It is principally the younger, Monk's Bay Sandstone Formation that is represented in these structural high areas (see discussion).

Lithologically the formation comprises generally well- to poorly-sorted unconsolidated sands and weakly consolidated sandstones, pebbly sandstones and ironstones with minor thin interbeds/laminae of mudstone. The individual beds are predominantly fining-upward, but with some coarsening-upward thicker beds where the formation itself is at its thickest. Beds are often bioturbated (with a nodular appearance when weathered where incomplete cementation occurs) and cross-bedded, but rarely contain ripple lamination or planar bedding. The sand is predominantly medium- to coarse-grained with varying proportions of fine sand. The sand grade material is mainly sub-rounded to rounded quartz with the coarser grains often having a polished surface. There are distinct coarse-grained beds with coarse- to very coarse-grained sand and some fine grade pebble material (generally less than 10 mm and often referred to as grit in the literature) and rare larger pebbles. Ironstone is present as beds with a pervasive 'framework' structure, as fragmentary framework beds, and as ooidal ironstones. Dark orange brown colouration is typical at outcrop although in boreholes a green glauconite is preserved. Limonitic ironstone ooids and fragmentary angular ironstone are found throughout the formation together with some phosphatic grains. Pebble clasts mainly comprise rounded quartz with phosphate and reworked bored material (some with overgrowths) together with some chert and sandstone and rare limonite. Dike (1972) described two sub-facies, namely a moderately- to well-sorted pebbly medium and coarse sand that predominates in the lower part of the formation and a very poorly sorted, pebbly, muddy sand heavily bioturbated by *Thalassinoides*, in the upper part.

2. Description of the Sections and Boreholes

The principal sections in the Monk's Bay Sandstone Formation are described below, starting with the stratotype at Monk's Bay, and then progressing from Red Cliff in the east to Compton Bay in the west. Sections described from previous work, principally

White (1921), Dike (1972) and Ruffell and Garden (1997) have been converted to a metric scale where necessary.

Monk’s Bay Stratotype Section

At Monk’s Bay and northward to Dunnose, the visible coastal succession comprises the upper part of the Sandrock Formation (Fig. 2), overlain successively by the Monk’s Bay Sandstone Formation and basal part of the Gault Formation. Early descriptions of the succession are given in White (1921, p.44) who repeated the section [SZ 5797 7801] given in Reid and Strahan (1889). He gives a total thickness of 10.45 to 10.52 m of beds for the Monk’s Bay Sandstone in Monk's Bay.

This description compares with that measured by one of us (Woods, 2009), during the current survey, between SZ 58152 78284 and 58092 78164 near Bonchurch. The section shows that the Monk’s Bay Sandstone Formation is between 10.21 to 10.25m thick (Fig. 3a and 4). This new description is proposed as the stratotype for the formation given that the thickest and most complete outcrop at Red Cliff, near Sandown, is usually overgrown, often obscured by slip material and relatively inaccessible.

At Monk’s Bay whilst much of the Sandrock Formation comprises beds of sandstone with occasional thin beds of mudstone, the few metres immediately below the base of the Monk’s Bay Sandstone (Fig. 3a beds 8 to 19) includes numerous beds and lenses of mudstone which forms a very distinctive interval at outcrop. This interval contains channel structures and conspicuous cross bedding suggesting a relatively shallow marine depositional environment. Dike (1972) considered the Sandrock Formation to represent a succession deposited in a fluctuating offshore, barrier bar, shoreline and near-shore environment representing, in its final depositional phase, a general regression and shoreline advance towards the south.

A strong upward colour change in the cliff section, from the orange-grey and yellow-grey sandstone of the Sandrock Formation, to dark, orange-brown sandstone, marks the sharp erosive base of the Monk’s Bay Sandstone Formation. Overall the formation is much coarser grained than the underlying Sandrock. The formation predominantly comprises coarse-grained and pebbly, bioturbated, ferruginous sandstone, with subordinate thin mudstone horizons. At Monk’s Bay the formation is divisible into three broad intervals, comprising a relatively massive-bedded central unit, about 5.5 m thick, sandwiched between lower and upper thin-bedded intervals. Dike (1972) considered the deposits of the Monk’s Bay Sandstone Formation (his Carstone) to be the basal deposits of the widespread mid-Albian transgression.

Place Fig. 2, Fig. 3a and Fig. 3b hereabouts

White (1921, p.44, Fig.11) recorded burrowing at the base of the Monk’s Bay Sandstone. In the currently exposed section this surface is seen to be slightly uneven and erosional terminating cross-bedded units within the underlying Sandrock Formation. The burrows penetrating the underlying Sandrock Formation contain a dark orange brown sandy/gritty clay-rich infill and can be clearly seen in the current exposure (Fig. 2). The base of the formation is marked by a 0.12 m thick pebble-rich unit (Bed 21), containing small, polished quartzite pebbles, up to 10 mm in size.

Elsewhere on the island, Garden (1991, Fig. 7D) identified a clast assemblage of rounded quartz pebbles but with significant numbers of Carboniferous ‘shelf chert’ and Jurassic-derived chert pebbles from three sites exposing this basal unit (Red Cliff, Rock and Compton Bay). Ruffell and Garden (1997, fig. 6, map 4), recorded phosphate, limonite and locally derived pebbles from the same bed at Compton Bay, St Catherine’s Point (Blackgang) and Reeth Bay [SZ 507 755]. The limonite is prevalent at Compton and Red Cliff, perhaps indicating proximity to the structural high that developed during Aptian/Albian times.

The overlying succession (Beds 22 to 34) comprises a few metres of alternating thin beds of dark grey mudstone and orange-brown sandstone. Both sandstones and mudstones are burrowed, with the softer mudstones weathering back to give a distinctive ‘ribbed’ appearance to this part of the succession.

Beds 35a, 35b and 36 collectively form the massive, sandstone-dominated part of the formation that includes a few thin beds of mudstone. These weather out prominently in the cliff profile. Bed 35a has a rather ‘nodular’ weathering appearance and contains abundant cemented burrows. Burrowing is much less obvious in the rest of this massive-bedded succession, and some small pebbles in Bed 36 have their long axis vertical to bedding, perhaps suggesting an effect of bioturbation or a high flow regime. Thin seams of much coarser, pebbly sandstone occur throughout this massive-bedded interval.

Place Fig. 4 hereabouts.

At Monk’s Bay access to the topmost 1.5 m of the Monks Bay Sandstone, immediately below the contact with the Gault, proved to be difficult during the survey and the succession could not be examined in detail. However the highest few metres of the Monks Bay Sandstone (Beds 37 to 39) are relatively thinly bedded, with three coarse-grained, pebbly sandstone beds overlain by thin mudstone horizons and thicker units of coarse sandstone.

Dike (1972) suggests that the massive units are attributable to sandwave and sand ridge formation in moderate currents with the thinner pebbly coarse-grained sandstones represent periodic storm deposition. Bioturbation has largely destroyed any internal structures but lower energy mud-rich laminae are preserved in parts of the succession.

Reference Sections

The Monk’s Bay Sandstone is exposed in the **Red Cliff (Sandown Bay)** section [SZ 626 855] (Fig.5) within the highest and poorly accessible part of the cliffs northeast of Yaverland. The formation can be followed within the cliff top northward but is generally obscured by landslip debris within a gully reaching to beach level that follows the steeply dipping zone of the Sandown Monocline. This is the thickest succession known for the formation on the Isle of Wight and comprises 22.17 m (White, 1921, p.30) of interbedded brown clayey pebbly sandstones (“grits”) and sand with quartz, quartzite and phosphatic pebbles and coarse ironstone sand grains. A graphic log for the succession at Red Cliff is given in Ruffell and Garden (1997) where 13.5 m (including an unspecified logging gap) are described as interbedded sands, clays and pebble beds.

Place Fig. 5 hereabouts.

The formation is exposed about 5 km to the west in the **Knighton Sand Pit** [SZ 574 866]. Here a near complete succession in the Sandrock Formation is seen and workings over recent years have gradually exposed the lower part of the Monk's Bay Sandstone Formation in a poorly accessible part of the quarry. A graphic log for the exposed Monk's Bay Sandstone Formation is shown in Fig. 6, together with three boreholes drilled to the north of the quarry face (Figs. 7a, b). These boreholes proved all but the highest part of the formation, the stratigraphically highest part being obscured by slipped Gault and Upper Greensand debris. It is estimated, by comparison with nearby boreholes and with the Red Cliff section, that only 2 to 4 metres of the formation are missing from the described boreholes.

Place Fig. 6, Fig. 7a and Fig. 7b hereabouts.

The current exposure at **Marvel Wood Sand Pit** [SZ 4988 8690], south of Newport in the centre of the island, shows much of the formation, including its base, but is otherwise greatly overgrown and was not logged in detail during the recent survey. White (1921) gives the following description (with the position of the Sandrock reconsidered) for the locality when a clearer section was available (Fig. 8).

	m
Monk's Bay Sandstone Formation	
Ferruginous grit, irregularly cemented in bands of iron oxide; small pebbles in lower part	3.66
Sandrock Formation	
Grey sand with fragments of clay, having the appearance of a reconstructed bed of the Sandrock Fm resting on the edges of the current-bedding below	0.91
White sands with current-bedding and fine seams of grey clay	9.14+

Place Fig. 8 hereabouts.

The current exposures confirm the view of Reid and Strahan (1889, p.42) that the 'reconstructed' grey sand should be considered as the uppermost Sandrock Formation and not the lowermost bed of the Monk's Bay Sandstone Formation as in White (1921, p.39) and that its apparent place above truncated cross-bedding and its disturbed nature can be regarded as a function of the burrowing at this horizon and/or the likelihood that there are a number of erosional surfaces within the Sandrock Formation itself. Certainly the exposure shown in Fig. 8 shows a clear base to the Monk's Bay Sandstone at the incoming of coarse-grained sandstone with ironstones at this locality.

About 3 km further to the south the **Rookley Brickworks s**ection is located at [SZ 5133 8395] in Owen (1971) and a log of the upper 9 m of the Monk's Bay Sandstone Formation, below the Gault Formation, is modified from that given by Dike (1972) (Fig. 9). The section is no longer visible, being within the heavily landscaped Rookley Country Park.

Place Fig. 9 hereabouts.

The formation outcrops around the southern downs of the island and can be seen in the section at **Luccombe (Shanklin) Chine** [SZ 583 793]. The section in the low cliffs adjacent to the chine is illustrated graphically in Ruffell and Garden (1997, Fig. 5) and comprises 3 m of fine- to medium-grained sand in three units representing the Sandrock Formation overlain by about 5.6 m of three fining-upward cycles of the Monk's Bay Sandstone and in turn overlain by the Gault. Each cycle commences with a coarse-grained sand unit fining-upward into weakly cross-bedded medium- to coarse-grained sand that includes bioturbation in places. The current exposure in the cliffs at the mouth of the chine is illustrated in Figure 10.

Place Fig. 10 hereabouts.

Further south within the area where the Monk's Bay Sandstone Formation is not visible the two boreholes at **Ventnor** provide a link southwards from the stratotype at Monk's Bay. Two cored boreholes drilled in the Undercliff landslide at Ventnor No. 2 (SZ57NE27 [SZ 55666 77576]) and No.3, (SZ57NE25 [SZ 55747 77510]), covering the basal Chalk Group through to the Sandrock Formation were donated to the BGS by the Isle of Wight Centre for the Coastal Environment.

Detailed logs of the relevant parts of these boreholes are shown in Fig. 11. The Monk's Bay Sandstone is incomplete in the Ventnor No. 2 borehole as a result of land sliding within the Undercliff. The sequence in Ventnor No 3, however, probably represents a complete succession through the formation as it contains the units that are lithologically transitional into the Gault.

Place Fig. 11 hereabouts.

Inland from Ventnor on the northern crop of the southern downs the Monk's Bay Sandstone Formation is frequently involved in and obscured by landslides. Three boreholes (Fig. 12) were drilled adjacent to **Hobbit House Farm** [SZ 521 786] through the Gault into the underlying Lower Greensand Group to capture a representative section through the Monk's Bay Sandstone and the boreholes probably record the whole of the formation, which is about 9 metres in this area. Some of the overlying Gault shown in Figure 12 is interpreted as slipped material.

Place Fig. 12 hereabouts.

The most westerly sections around the southern downs within the Monk's Bay Sandstone Formation are at **Blackgang** [SZ 486 768]. The most recently described section is that of Ruffell and Garden (1997, Fig. 5) that gives a thickness for the formation of about 6.4 m. Reid and Strahan (1889, p. 57 to 59; see also Ibbetson and Forbes, 1845) described the occurrence of the formation eastward of St Catherine's Point [SZ 508 706] and within the much disturbed westward outcrop of the Undercliff landslide. At that time the formation was not considered to be present in situ within blocks containing phosphorite-cemented coarse-grained sandstone nodules on the foreshore from which Jackson (1939) described a significant fauna. Subsequently

Casey (1961) described the fauna from similar nodules within the formation in Reeth Bay [SZ 507 756] that he considered to be in situ. In the cliff below Niton the memoir (White, 1921) described 3.4 m of the formation as interbedded brown grit and clay resting on a thin pebbly and ferruginous band.

Six boreholes were drilled in the area of **Mottistone** immediately to the east of Longstone Cottages [SZ 4075 8429] in the moderately dipping limb of the Brighstone monoclinal feature. Four of these boreholes penetrated part of the Monk's Bay Sandstone Formation and a correlation of these is shown in Figure 13 and this gives an approximate thickness of 6 metres for the Monk's Bay Sandstone Formation.

Place Fig. 13 hereabouts.

The most westerly occurrence of the Monk's Bay Sandstone on the island is at **Compton Bay** [SZ 367 852] where the section was described by White (1921, p. 28) is 1.83 m thick (Fig. 14). The **Compton Chine borehole** drilled adjacent to the mere at the top of the cliff proved a complete succession through the Monk's Bay Sandstone. As interpreted, the graphic log (Fig. 15) shows that the formation thins here to only 1 m. However, if the sandy clay above is considered to be part of the Monk's Bay Sandstone Formation, rather than the basal Gault, then it may be 2.5m thick. Ruffell and Garden (1997) give an expanded thickness of about 3 m for their section in the cliffs below.

Place Fig. 14 and Fig. 15 hereabouts.

A number of additional sites (listed in Table 2) many of which are now overgrown or otherwise obscured, are described in Reid and Strahan (1889) and White (1921, p.39 to 44). The boreholes that encountered the formation and are described in this paper are shown in Table 3

Location	**Grid Reference**
Rock	SZ 4251 8397
Marvel Wood	SZ 4988 8690
Billingham Cottages	SZ 4831 8244
Birchmore	SZ 5062 8529
Whitecroft	SZ 4989 8631
Knighton Brook	SZ 5677 8676
Itchall	SZ 5198 7930
Itchall	SZ 5219 7961

Table 2. Additional locations described in White (1921) for the Monk's Bay Sandstone Formation.

Location	**Locality Grid Reference**	**Registered Number(s)**
Knighton Sand Pit	SZ 575 867	SZ58NE 98 to 100
Whitwell (Hobbit House Farm)	SZ 520 786	SZ57NW 51 to 53
Mottistone	SZ 408 843	SZ48SW 26 to 31
Compton Chine	SZ 36935 85182	SZ38NE 30

Ventnor[*]	SZ 557 775	SZ57NE 27 and 25

Table 3. The BGS boreholes described in this paper.

[*]Two cores, derived from the landslide studies in Ventnor, and donated to BGS by the Isle of Wight Centre for the Coastal Environment (Ventnor No2 and No3) were re-examined in detail for the successions through the Monk's Bay Sandstone Formation.

3. Biostratigraphy

Macro-biostatigraphical framework

The macrofossil biostratigraphy of the Aptian and Albian is based on ammonites, and this forms the framework for the calibration of other biostratigraphical schemes based on microfossils (see below). In recent years variations of two different macrofossil schemes have been proposed, and the relationship between these is shown on Figure 16.

Ammonites and other diagnostic macrofossils are generally very rare in the Monk's Bay Sandstone, and no new specimens were found during the current work. Previous investigations have shown that the formation is coextensive with the *D. mammillatum* Superzone sensu Owen (1988), which forms the youngest part of the Early Albian (Fig. 16). This biostratigraphical interval comprises a complex succession of zones and subzones (Fig. 16), and many localities exposing this interval in southern, central and eastern England show mixing or breaks in the faunal succession, caused by laterally variable marine erosion. Casey (1961) believed that the representation of his '*mammillatum* Zone' was relatively complete in the Isle of Wight, but the more refined scheme of Owen (1988) shows that some horizons are unrepresented.

Place Fig. 16 hereabouts.

The unconformity between the top of the Sandrock and the base of the Monks Bay Sandstone cuts out the highest part of the *L.* (*L.*) *tardefurcata* Zone, equating with the *L. regularis* Subzone (Casey, 1961). A much larger stratigraphical break occurs in the north of the Isle of Wight, where boreholes proved Jurassic strata beneath Monks Bay Sandstone (Gale et al., 1996). Above the unconformity, the basal part of the formation contains ammonites indicative of the *S. kitchini* Subzone, and this interval is also indicated by many of Casey's (1961) faunal records from the formation, including *Anadesmoceras bayeli* (Spath) from Blackgang and Reeth Bay, and *Sonneratia* (*S.*) *parenti* Jacob and *Cleoniceras* (*C.*) *morgani* Spath from Compton Bay. Owen (1988) recorded the top of the *S. chalensis* Zone (*C. floridum* Subzone) in the Monks Bay Sandstone, and *Otohoplites* at Reeth Bay (Casey, 1961) which suggests that the upper part of the *mammillatum* Superzone (*O. auritiformis* Zone) is present. The top of the Monks Bay Sandstone on the coast at Compton Bay and Bonchurch, and inland at Rookley Brickworks, contains records of *Hoplites* (*Isohoplites*) *eodentatus* Casey (Owen, 1971a), conspecific with *Pseudosonneratia* (*Isohoplites*) *steinmanni* Jacob which is the subzonal index for the top of the *mammillatum* Superzone (Owen, 1988).

On the Isle of Wight there is no evidence of the *S.* (*G.*) *perinflatum* Subzone at the base of the *S. chalensis* Zone; the *O. bulliensis* Subzone, near the top of the *O. auritiformis* Zone, has yet to be proved anywhere in the UK (Owen, 1988).

Foraminiferal zonation: Previous work

The best known early Albian foraminifera are from Germany and France (e.g. Hecht, 1938; Magniez-Jannin, 1975) where two foraminiferal zones have been recognised (Price, 1977) (Fig. 17). In Britain, early Albian foraminiferal data comes from two studies: the Speeton Clay Formation (Mitchell and Underwood, 1999) and the Carstone Formation (Dilley, 1969) both in Yorkshire, although assemblages in the latter formation are rare and patchily distributed. The established foraminiferal zonation for the mid and late Albian, based on the work of Carter and Hart (1977), commences with zone 3 (subzone 3i).

Place Fig. 17 hereabouts.

Microfaunal Results from the BGS Boreholes

The microfaunal evidence from the BGS boreholes is sparse with significant parts of the successions proving barren. However there is some evidence to place the base and top of the Monk's Bay Sandstone Formation within the schemes shown in Fig. 17. The results from the base of the Gault Formation further limit the subzonal age of the top of the Monk's Bay Sandstone.

From macropalaeontological data it can be concluded that the Sandrock Formation is of *H. Jacobi*, *Proleymeriella schrammeni* and *L. tardefurcata* zonal (*Leymeriella acuticostata s*ubzonal) age. Foraminiferal Zone 1 should be confined to the Sandrock Formation but this could not be confirmed from the examination of the samples derived from the BGS boreholes.

As already stated the Sandrock and Monk's Bay Sandstone formations are separated by an erosive boundary, representing all or part of the *L. regularis* Subzone. However a single sample from the base of the Monks Bay Sandstone in a borehole at Knighton contained tubular foraminifera resembling *Hyperammina*/'*Rhizammina* cf *dichotomata'*. This occurrence suggests the presence of Foraminifer Zone 1. Either the formation at this locality is older (perhaps *regularis* zonal age) or the foraminiferal zonal boundary is stratigraphically higher in the Isle of Wight. Reworking, perhaps the most likely scenario, cannot be ruled out, but if this were the case, then the survival of these agglutinated foraminifera is surprising.

Early Albian Foraminifera from the majority of samples within the Monks Bay Sandstone Formation comprise predominantly long ranging and patchily distributed taxa, often of small dimensions, including *Glomospirella gaultina*, *Reophax minuta*, *Cribrostomoides nonionoides rotunda* and *Trochammina concavus.* At the top of the formation *Cribrostomoides nonoionoides rotunda*, *Cribrostomoides concavus*, *Arenobulimina macfadyeni* and *Ammobaculites* sp cf *parvispira* were recorded. This association within the formation are typical of Foraminiferal Zone 2.

The foraminiferal assemblages recorded from the BGS boreholes within the overlying Gault Formation of the Isle of Wight differ considerably from those of Kent and Sussex. Foraminifera are sparse, associations are of low diversity, and faunas are almost entirely agglutinated. The Gault is characterised by *Arenobulimina* *macfadyeni*, *Tritaxia singularis*, *Cribrostomoides nonionoides rotunda*, *Reophax minuta*, *Haplophragmoides chapmani*, *Trochammina* cf *concavus*, *Trochammina* sp cf *wetteri*, *Ammodiscus cretaceus* and *Glomospirella gaultina*, indicating a position in Foraminiferal Zones 3 and 4 and above.

4. Sedimentation and correlation

Although the Monks Bay Sandstone Formation is geographically restricted to the Isle of Wight, it is coeval with similar coarse-grained, glauconitic and phosphate-bearing sediments belonging to the *D. mammillatum* Superzone, of Early Albian age, across southern England, Bedfordshire, East Anglia, ~~and~~ Lincolnshire and east Yorkshire. In the Weald and Bedfordshire, these strata have traditionally been known as 'Junction Beds' (e.g. Owen, 1972; 1992), and in East Anglia, Lincolnshire and east Yorkshire as 'Carstone'. Hopson et al. (2008) introduced the name Munday's Hill Phosphatic Sandstone Formation for the Bedfordshire 'Junction Beds' and the slightly older (*L. tardefurcata* Zone, *L. regularis* Subzone) Shenley Limestone Member. Like the Monks Bay Sandstone, the 'Junction Beds' and Carstone show great lateral variability in their development, reflected in their detailed biostratigraphy, thickness and changing relative proportion of dominant lithological components. This variability reflects a dynamic depositional environment that was strongly influenced by Early Albian palaeogeography and basin architecture. For example, the unusually expanded 'Junction Beds' seen at Folkestone probably reflect the role of extensional fault control (Ruffell and Wach, 1998), whilst further west in Sussex, equivalent sediments ('Iron Grit') are highly condensed on the flanks of an emergent structure, with primary iron-enrichment occurring in a lagoonal or marginal marine setting (Anderson, 1986). Further north, across the East Midlands Shelf, the base and top of the Carstone both appear to be younger than elsewhere (Mitchell and Underwood, 1999).

The unconformity immediately underlying the Monk's Bay Sandstone represents a sequence boundary, reflecting a major relative fall in sea level and named LG4 in the eastern Weald by Hesselbo et al. (1990). Whilst this sequence boundary can be matched with a conspicuous erosion surface at the base of correlative strata at many localities across central and eastern England, it is less obvious in the expanded Weald successions. Here, strata equivalent to the Monk's Bay Sandstone are represented by phosphate-rich sandstones at the top of what is conventionally regarded as the Folkestone Formation, and designated 'Gault – Lower Greensand Junction Beds' by Owen (1992). There are two candidate positions for sequence boundary LG4 in the eastern Weald; in the expanded Folkestone succession these are either at the base of the locally developed *mammillatum* Superzone (*S. kitchini* Subzone), or at the base of a conspicuous concentration of phosphates slightly higher in the succession ('Main Mammillatum Bed' of Casey, 1961), spanning the *S. chalensis* and *O. auritiformis* zones (Hesselbo et al., 1990). The 'Main Mammillatum Bed' can also be interpreted as the product of condensed sedimentation associated with a maximum flooding surface (Hesselbo et al., 1990); this and the presence of the *S. kitchini* Subzone in the Monk's Bay Sandstone favours the lower horizon as the position of the sequence boundary.

In the Isle of Wight, the *L. regularis* Subzone (Casey, 1961) is missing below the sequence boundary and above it the Monk's Bay Sandstone and its lateral equivalents represent a major transgressive sedimentary package, with deposition in shallow and offshore marine settings (Ruffell, 1992; Ruffell & Wach, 1991). The sediment includes material (pebbles) reworked from Carboniferous and Jurassic strata, the weathered and oxidized pyritic mudstones of the latter contributing to the iron-rich character of the Monk’s Bay Sandstone (Garden, 1991; Ruffell & Garden, 1997). For example, a considerable proportion of limonite grains and small clasts is present in the Monk’s Bay Sandston at Compton and Red Cliff, indicating proximity to a structural high source area.

The change in the depositional regime associated with the Monk’s Bay Sandstone is highlighted by its thickness trend and distribution (Ruffell, 1992, fig. 4). The formation’s westerly thinning, and presence north of the faulted margin of the Isle of Wight palaeo-high, contrasts with underlying units displaying southerly thickening and confinement south of this palaeo-high. However, re-examination of borehole records in the northern part of the Isle of Wight suggests that some occurrences of Monk’s Bay Sandstone might be underlain by older Lower Greensand Group sediments. A number of well-records contain descriptions of very fine- to fine-grained well-sorted sands with an argillaceous matrix (e.g. Bouldnor Copse No1; SZ39SE1 [SZ38537 90179]), or show a lower unit beneath coarse-grained sandstone and pebbly sandstone that comprise very variable but generally finer-grade sands and argillaceous beds some with plant remains (e.g. Portsdown No2; SU60NW5 [SU 6393 0737]). If these deposits represent a marine depositional environment it suggests that marine transgressions onto the Isle of Wight palaeo-high were complex, episodic and earlier than previously supposed. Further to that hypothesis, structural observations during the resurvey of the island suggest that the development of the Isle of Wight palaeo-high and eventually the monoclinal structure was not simple and that generally north – south orientated faulting divides the monoclinal areas into blocks with slightly differing strike orientations. It is very likely that these structures are nucleated on earlier Jurassic structures and that mid-Cretaceous deposition and palaeogeography is not be a function of eustacy alone. There is likely to be a tectonic influence to the distribution of Lower Greensand Group sediments, and the preservation/erosion of thin Lower Greensand Group sediments below the Monk’s Bay Sandstone is therefore ~~be~~ related to differential block movement (a far-field ‘Alpine’ tectonic influence perhaps) as well as general regressive/transgressive eustatic cycles.

It is noticeable that coastal sections in the Monk’s Bay Sandstone between Monk’s Bay and Luccombe Chine show a persistent depositional pattern, comprising thinner bedded intervals in the lower and upper parts, and a thicker, massively-bedded and more conspicuously bioturbated central part. This pattern is formed by thin units of intercalated mudstone in the lower and upper parts of the succession, with few mudstone horizons in the central part. The mudstones indicate lower-energy phases of marine deposition compared to the intervening coarse, pebbly sandstones, and may be primary evidence for pulses of marine inundation during transgression. The conspicuous bioturbation in the massive beds could have destroyed mudstone horizons if they were ever present, but may also indicate relatively less reworking during deposition compared to adjacent pebbly sandstone units.

Acknowledgements

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P. M. Hopson, I.P. Wilkinson, M. A. Woods and A.R. Farrant publish with the permission of the Executive Director of the British Geological Survey (N.E.R.C.).

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List of Figures

Fig.1. The outcrop of the Monk’s Bay Sandstone Formation on the Isle of Wight, including the locations of the principal exposures and boreholes mentioned in the text (outcrop derived from BGS, 1976 without modification).

Fig. 2. The strongly colour-contrasted and burrowed boundary between the pale yellow, fine-grained, cross-bedded, sandstone of the Sandrock Formation (below) with the coarse-grained, pebbly, ferruginous sandstone of the Monk’s Bay Sandstone

Formation (above) at the stratotype in Monk’s Bay. Burrows, infilled with coarse-grained sand, extend downwards from the Monk’s Bay Sandstone Formation into the Sandrock Formation. Field of view 0.35 x 0.5 m approx. BGS image P732202. [SZ 58099 78122].

Fig. 3a. The stratotype section of the Monk’s Bay Sandstone Formation at Monk’s Bay near Bonchurch, Isle of Wight [SZ 581 782] (after Woods, 2009, fig 12.). See Fig. 3b for key.

Fig. 3b. Key to Figure 3a and subsequent lithological graphic logs. Each log shows a representation of the maximum grain size up to very coarse-grained sand based on visual examination.

Fig. 4. View of the Monk’s Bay section from [SZ 58099 78122] looking north. The pale yellow sandstones of the Sandrock Formation overlain, in the mid-cliff, by the orange-brown coarse-grained sandstones of the Monk’s Bay Sandstone Formation (arrow marks the boundary). The basal Gault Formation is evident within the shallower slopes at the top of the exposure. Here the formation about 10 m thick. BGS image P 732203 [SZ 58099 78122].

Fig. 5. The section northeast of Red Cliff. The base of the Monk’s Bay Sandstone Formation is arrowed. It lies at the distinct colour change from the paler sandstones of the Sandrock Formation below, to the orange-coloured coarse sandstones of the Monk’s Bay Sandstone Formation above. BGS image P732243 [SZ 62199 85436].

Fig. 6. The section of Monk’s Bay Sandstone Formation at Knighton Sand Pit and the logs from the three cored boreholes completed to the north of the exposure visible in 2008. See Fig. 3b for key.

Fig. 7a. The lower part of the exposure of Monks Bay Sandstone Formation exposed in the Knighton Sand Pit [SZ 57474 86712]. At this locality the formation rests with a sharp erosive contact (arrowed) (hoe head 0.6 m long) on laminated/finely-bedded sandy clayey silts at the top of the the Sandrock Formation. BGS image P683907.

Fig. 7b. The upper part of the Monk’s Bay Sandstone Formation at the Knighton Sand Pit (hammer 0.28 m). BGS image P683932.

Fig. 8. Marvel Sand Pit [SZ 4992 8687]. Boundary (arrowed), between the Sandrock Formation and the Monks Bay Sandstone Formation, just below ferruginous ironstone band. Field of view approx 40 x 55 m. BGS image P 692204.

Fig. 9. Graphic log for Rookley Brickworks [SZ 5133 8395] modified after Dike (1972). See Fig. 3b for key.

Fig. 10. The contact (arrowed) of the Sandrock Formation and the Monk’s Bay Sandstone Formation in the cliff adjacent to Luccombe Chine [SZ 58325 79278], Isle of Wight. BGS image P732232.

Fig. 11. Graphic borehole log for The Monk’s Bay Sandstone Formation and adjacent units from the Ventnor No. 2 and 3 boreholes. See Fig. 3b for key.

Fig. 12. Graphic log, as a composite of the three boreholes completed at Hobbit House Farm, Whitwell. See Fig. 3b for key.

Fig. 13. Correlation of the four boreholes at Mottistone. See Fig. 3b for key.

Fig. 14. Compton Bay. The attenuated Monk's Bay Sandstone Formation, 1.83 m thick, exposed at beach level adjacent to Compton Chine. Dark glauconitic sandy mudstone of the Sandrock Formation is visible below and dark grey basal sandy mudstone of the Gault Formation above. [SZ 436736 085214]. Hammer 28 cm. BGS image P732435.

Fig. 15. Graphic log of the Monk’s Bay Sandstone at Compton Chine borehole compared to that from Compton Bay (Ruffell and Garden, 1997). See Fig. 3b for key.

Fig. 16. The ammonite zonal scheme adopted by Casey (1961) and others for the Early and Mid Albian of the UK, compared to that of Owen (1999, 2007). 1. *Leymeriella acuticosta* in Europe; 2. *Farnhamia farnhamensis* is synonymn of *Proleymeriella schrammeni* (e.g. Mutterlose et al. 2003).

Fig. 17 The lithostratigraphy of the Lower and Middle Albian of southern and eastern England related to the ammonite zones/subzones (Casey 1961, Owen 1999). Shaded area depicts the erosional gap in the succession, which Casey (1961) considered to occupy the entire *L. regularis* Zone. Ranges of selected Early Albian foraminifera and the foraminiferal zonation are correlated to ammonite biostratigraphy (not the lithostratigraphy).

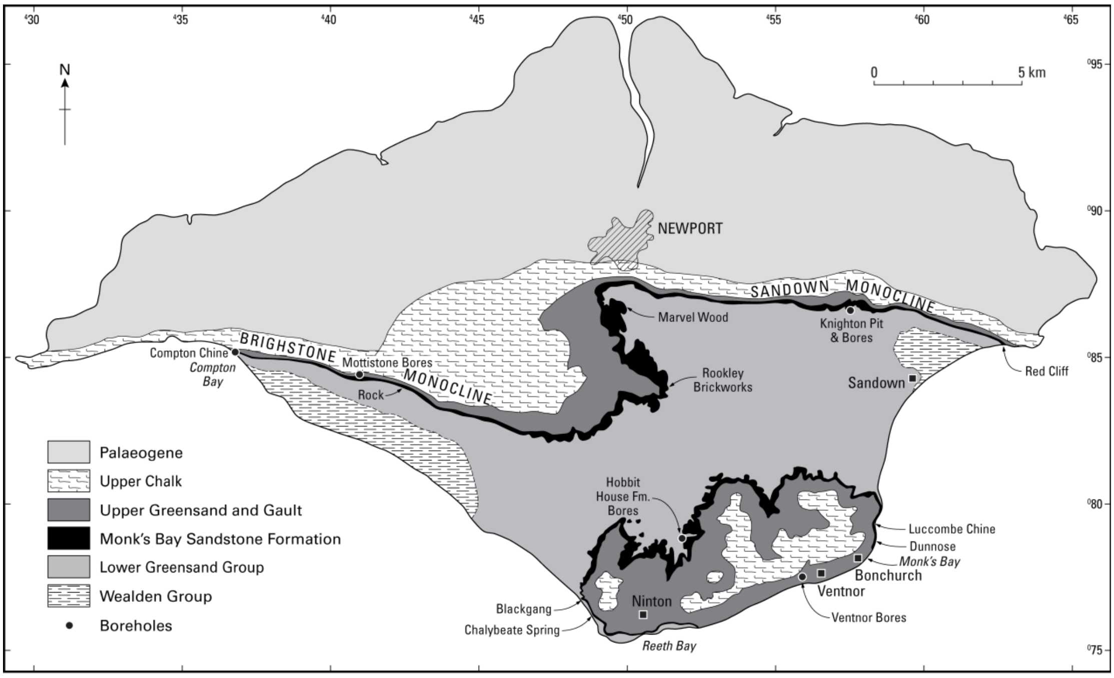
List of Tables

Table 1. Simplified litho- and chrono-stratigraphy of part of the Lower Cretaceous of the Isle of Wight.

Table 2. Additional locations described in White (1921) for the Monk’s Bay Sandstone Formation.

Table 3**.** The BGS boreholes described in this paper.

Fig 1.



NEWPORT
SANDOWN MONOCLINE
BRIGHSTONE MONOCLINE
Marvel Wood
Knighton Pit & Bores
Compton Chine
Compton Bay
Mottistone Bores
Rock
Rookley Brickworks
Sandown
Red Cliff
Hobbit House Fm. Bores
Luccombe Chine
Dunnose
Monk's Bay
Bonchurch
Ventnor
Ventnor Bores
Ninton
Blackgang
Chalybeate Spring
Reeth Bay
0
5 km
N
Palaeogene
Upper Chalk
Upper Greensand and Gault
Monk's Bay Sandstone Formation
Lower Greensand Group
Wealden Group
Boreholes

Fig. 2

Fig. 3a

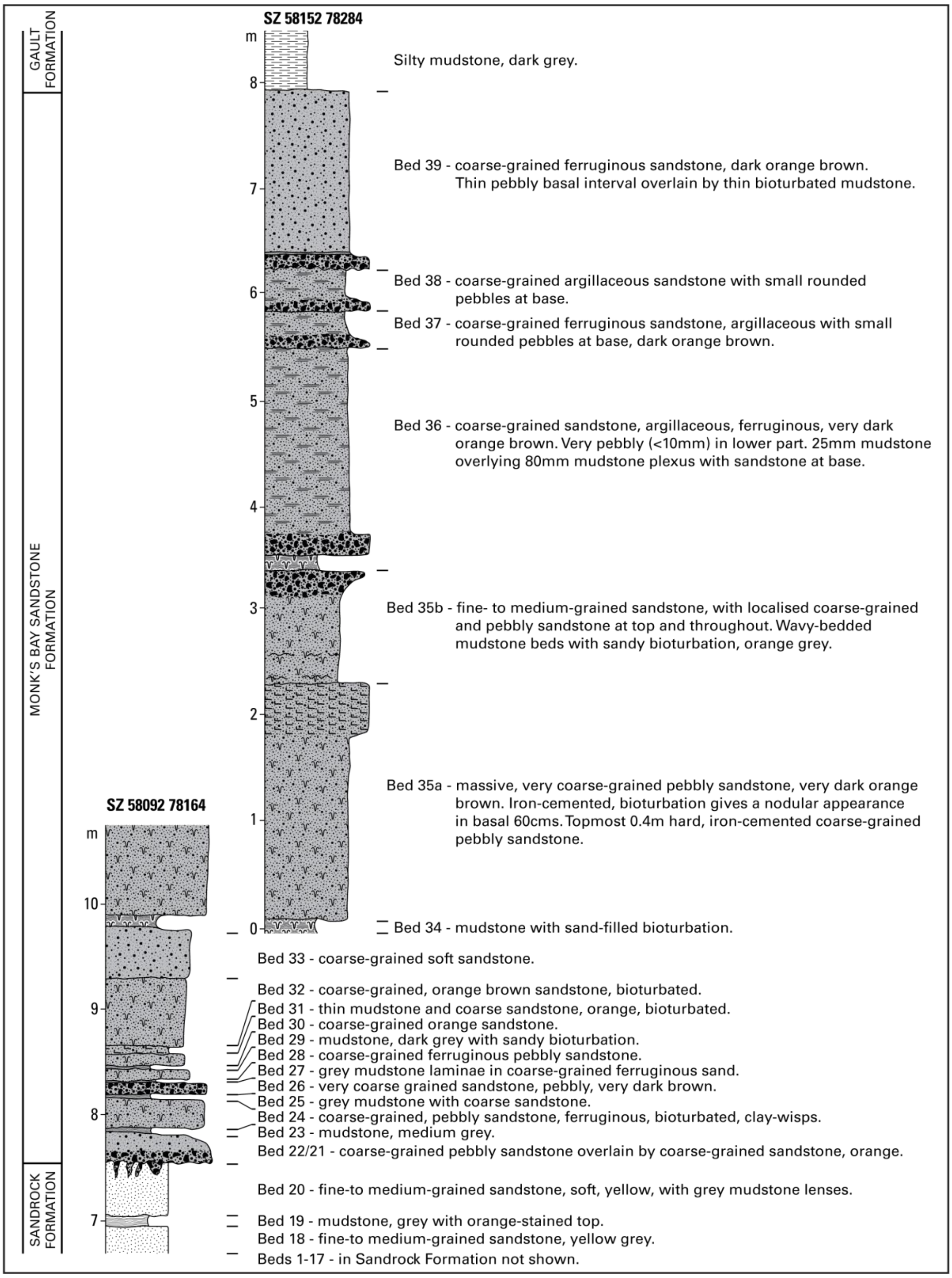

GAULT FORMATION
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
SZ 58152 78284
m
8
7
6
5
4
3
2
1
0
Silty mudstone, dark grey.
Bed 39 - coarse-grained ferruginous sandstone, dark orange brown. Thin pebbly basal interval overlain by thin bioturbated mudstone.
Bed 38 - coarse-grained argillaceous sandstone with small rounded pebbles at base.
Bed 37 - coarse-grained ferruginous sandstone, argillaceous with small rounded pebbles at base, dark orange brown.
Bed 36 - coarse-grained sandstone, argillaceous, ferruginous, very dark orange brown. Very pebbly (<10mm) in lower part. 25mm mudstone overlying 80mm mudstone plexus with sandstone at base.
Bed 35b - fine- to medium-grained sandstone, with localised coarse-grained and pebbly sandstone at top and throughout. Wavy-bedded mudstone beds with sandy bioturbation, orange grey.
Bed 35a - massive, very coarse-grained pebbly sandstone, very dark orange brown. Iron-cemented, bioturbation gives a nodular appearance in basal 60cms. Topmost 0.4m hard, iron-cemented coarse-grained pebbly sandstone.
Bed 34 - mudstone with sand-filled bioturbation.
SZ 58092 78164
m
10
9
8
7
Bed 33 - coarse-grained soft sandstone.
Bed 32 - coarse-grained, orange brown sandstone, bioturbated.
Bed 31 - thin mudstone and coarse sandstone, orange, bioturbated.
Bed 30 - coarse-grained orange sandstone.
Bed 29 - mudstone, dark grey with sandy bioturbation.
Bed 28 - coarse-grained ferruginous pebbly sandstone.
Bed 27 - grey mudstone laminae in coarse-grained ferruginous sand.
Bed 26 - very coarse grained sandstone, pebbly, very dark brown.
Bed 25 - grey mudstone with coarse sandstone.
Bed 24 - coarse-grained, pebbly sandstone, ferruginous, bioturbated, clay-wisps.
Bed 23 - mudstone, medium grey.
Bed 22/21 - coarse-grained pebbly sandstone overlain by coarse-grained sandstone, orange.
Bed 20 - fine-to medium-grained sandstone, soft, yellow, with grey mudstone lenses.
Bed 19 - mudstone, grey with orange-stained top.
Bed 18 - fine-to medium-grained sandstone, yellow grey.
Beds 1-17 - in Sandrock Formation not shown.

Fig. 3b

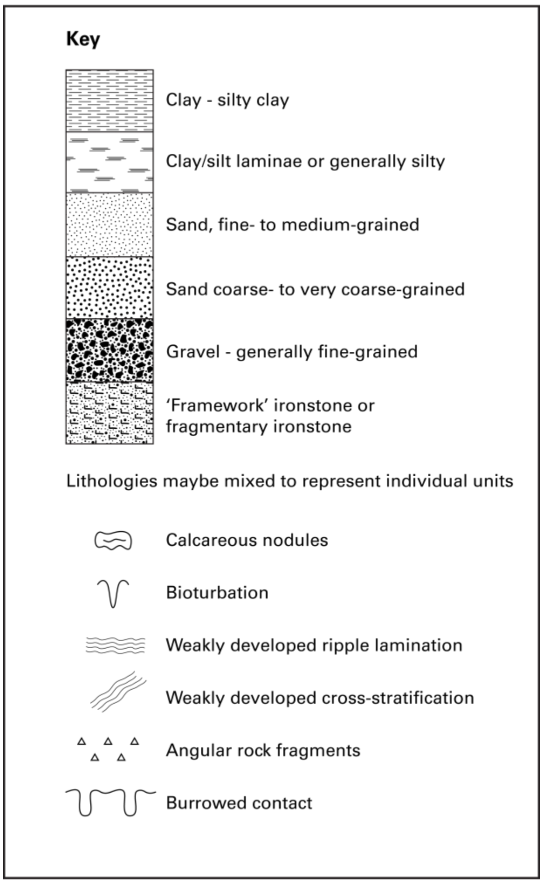

Key
Clay - silty clay
Clay/silt laminae or generally silty
Sand, fine- to medium-grained
Sand coarse- to very coarse-grained
Gravel - generally fine-grained
'Framework' ironstone or
fragmentary ironstone
Lithologies maybe mixed to represent individual units
Calcareous nodules
Bioturbation
Weakly developed ripple lamination
Weakly developed cross-stratification
Angular rock fragments
Burrowed contact

Fig. 4

Fig. 5

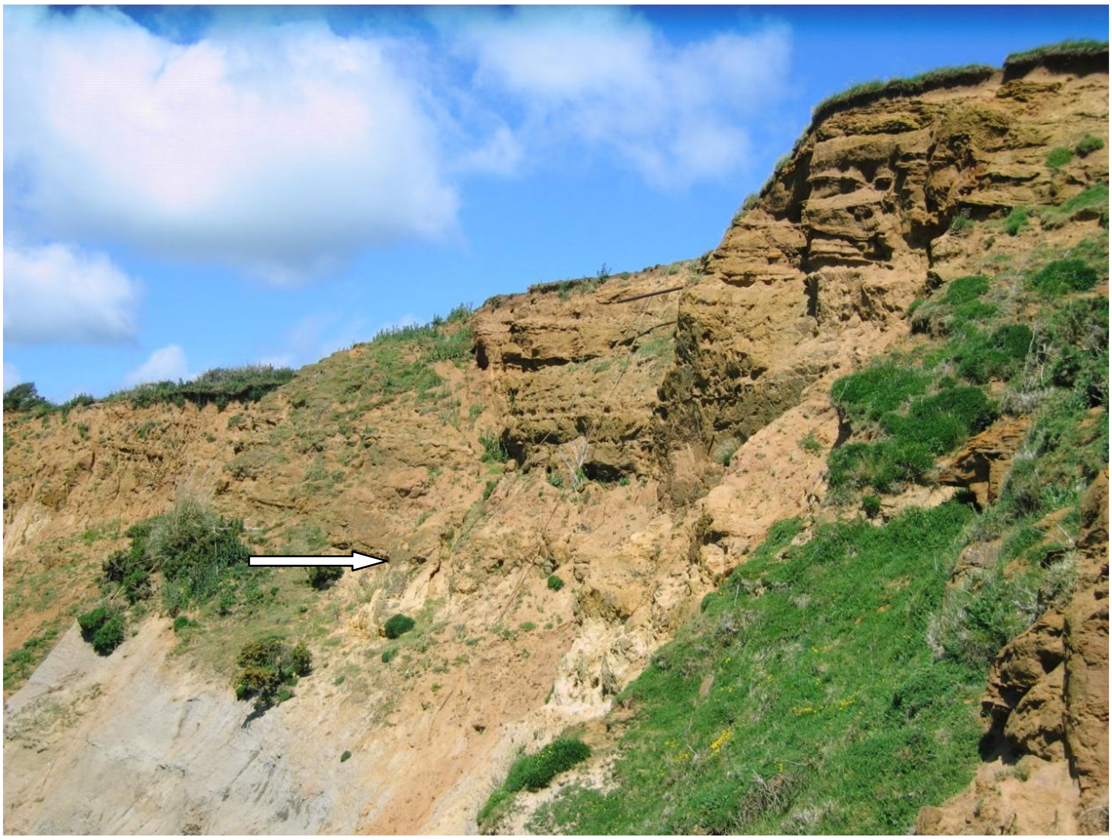
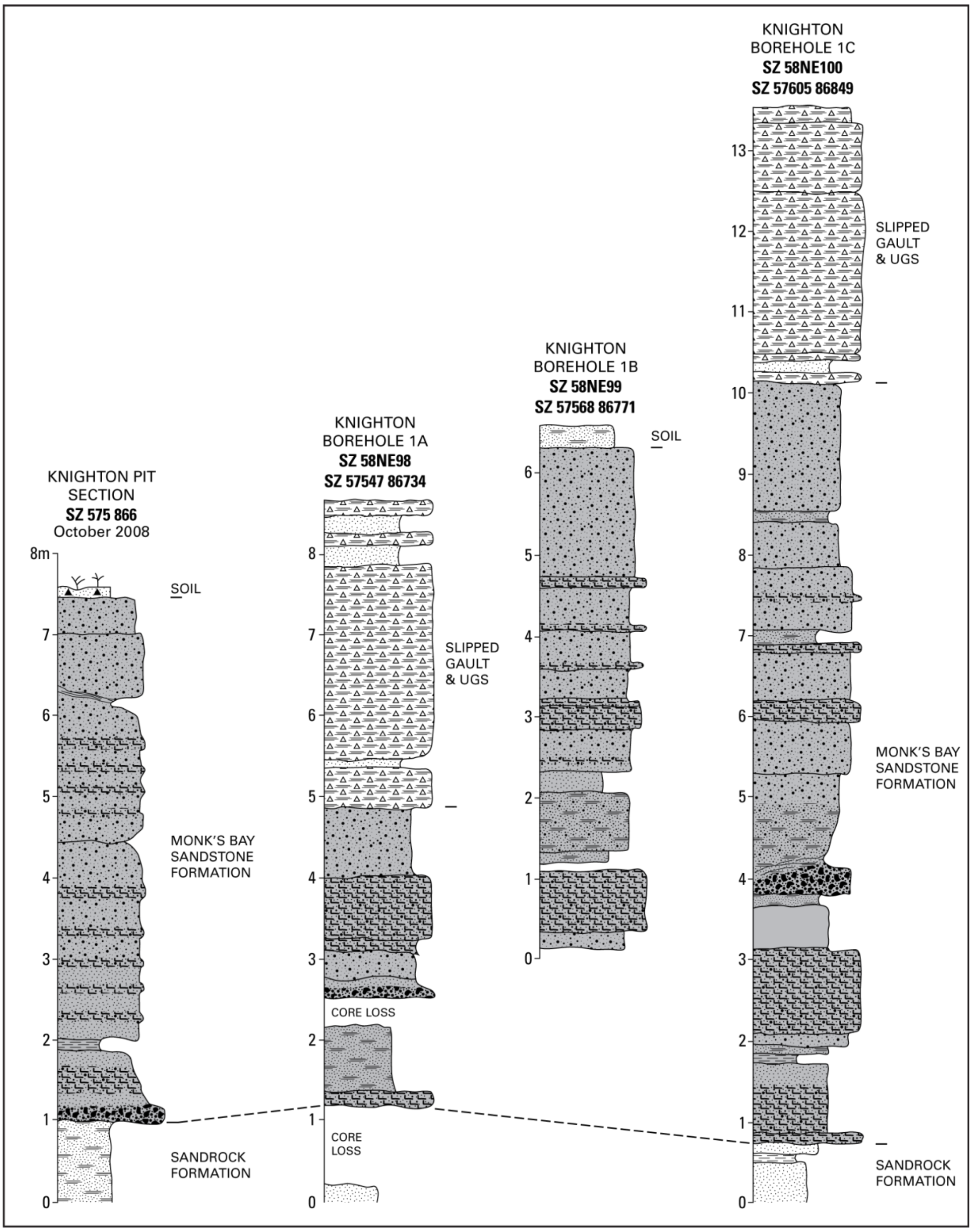


Fig. 6



KNIGHTON PIT SECTION
SZ 575 866
October 2008
SOIL
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
KNIGHTON BOREHOLE 1A
SZ 58NE98
SZ 57547 86734
SLIPPED GAULT & UGS
CORE LOSS
CORE LOSS
KNIGHTON BOREHOLE 1B
SZ 58NE99
SZ 57568 86771
SOIL
KNIGHTON BOREHOLE 1C
SZ 58NE100
SZ 57605 86849
SLIPPED GAULT & UGS
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
8m

Fig. 7a

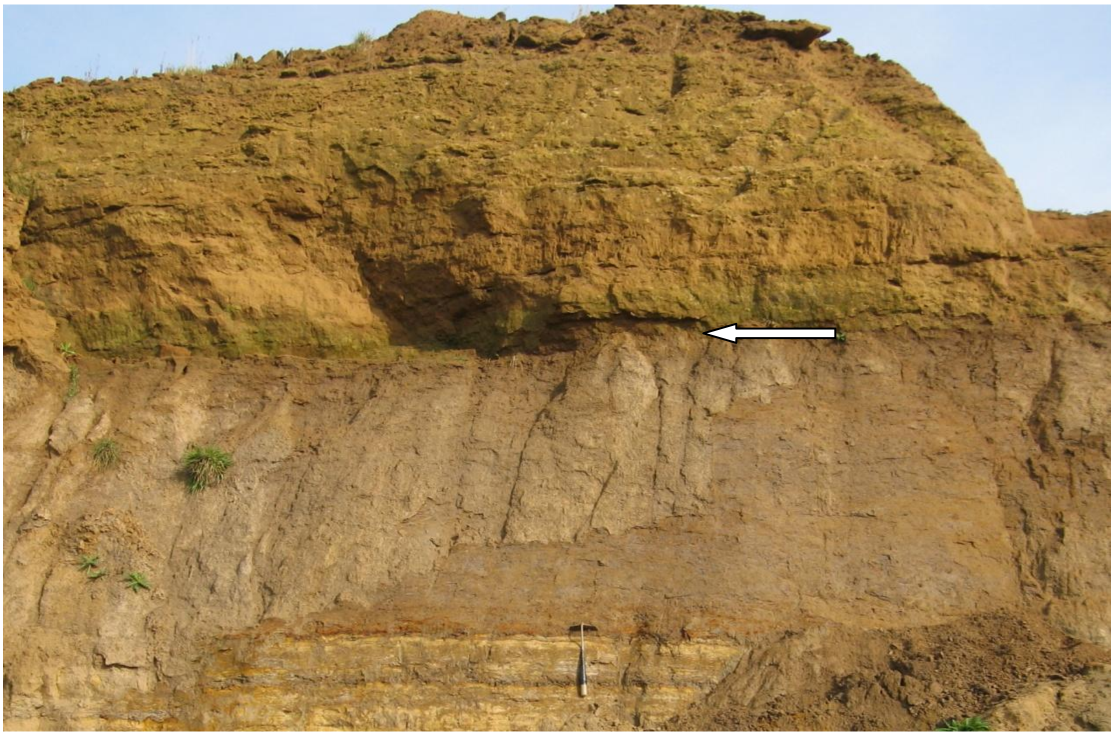


Fig. 7b

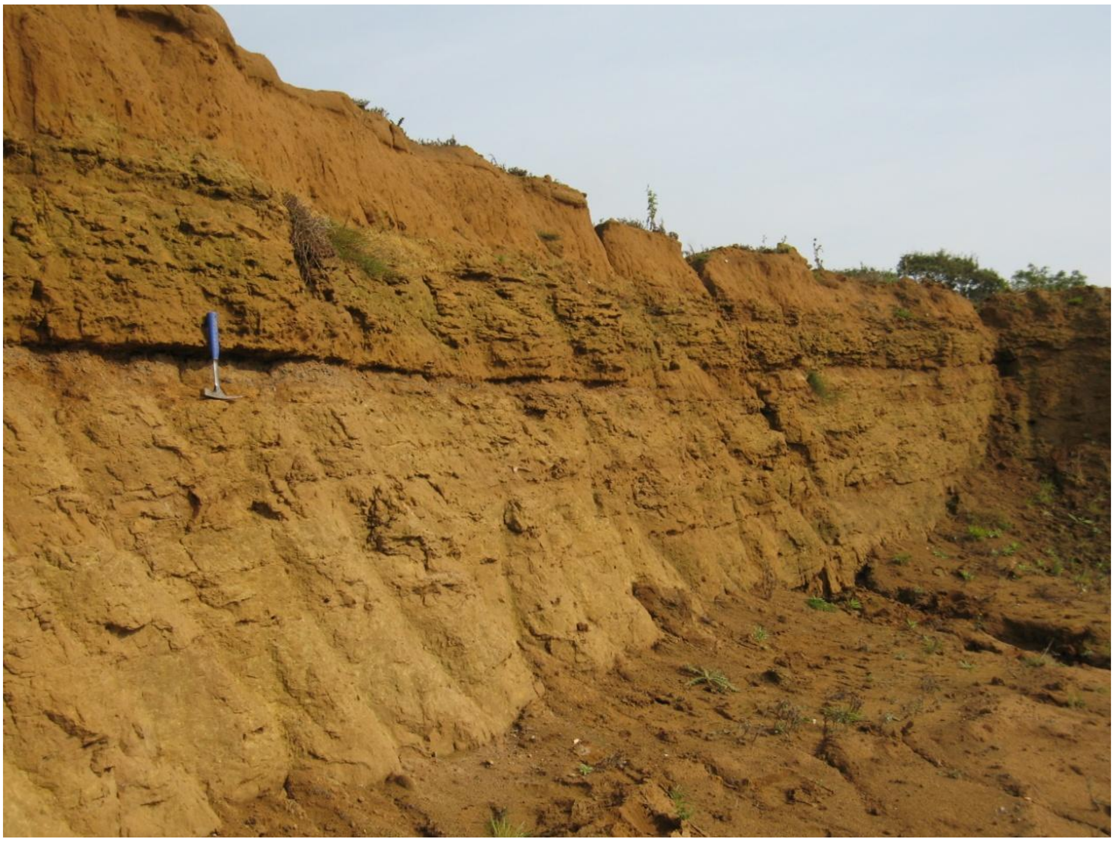


Fig. 8

Fig. 9

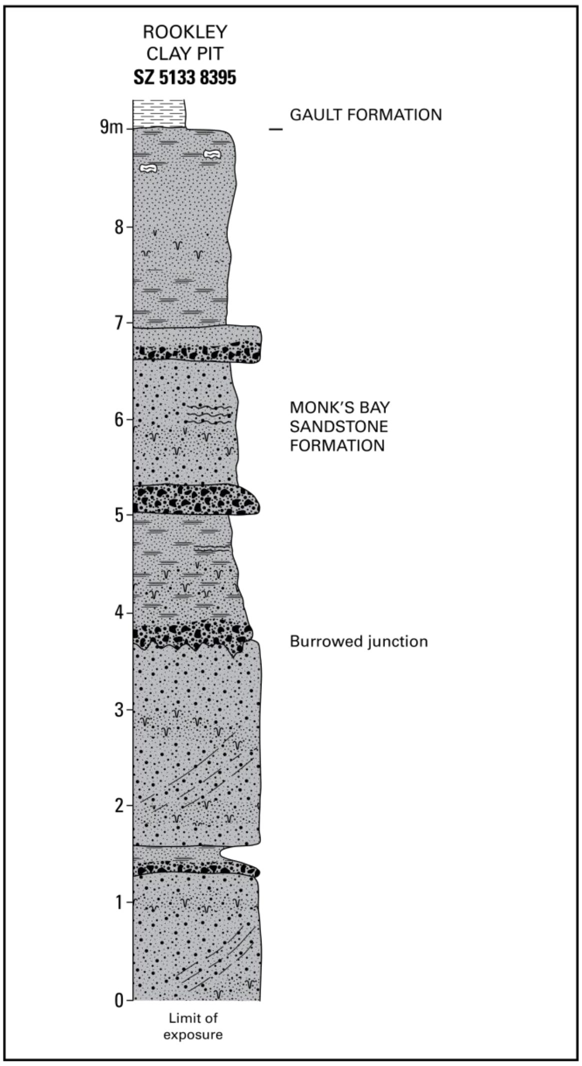

ROOKLEY
CLAY PIT
SZ 5133 8395
GAULT FORMATION
9m
8
7
6
5
4
3
2
1
0
MONK'S BAY
SANDSTONE
FORMATION
Burrowed junction
Limit of
exposure

Fig. 10

Fig. 11

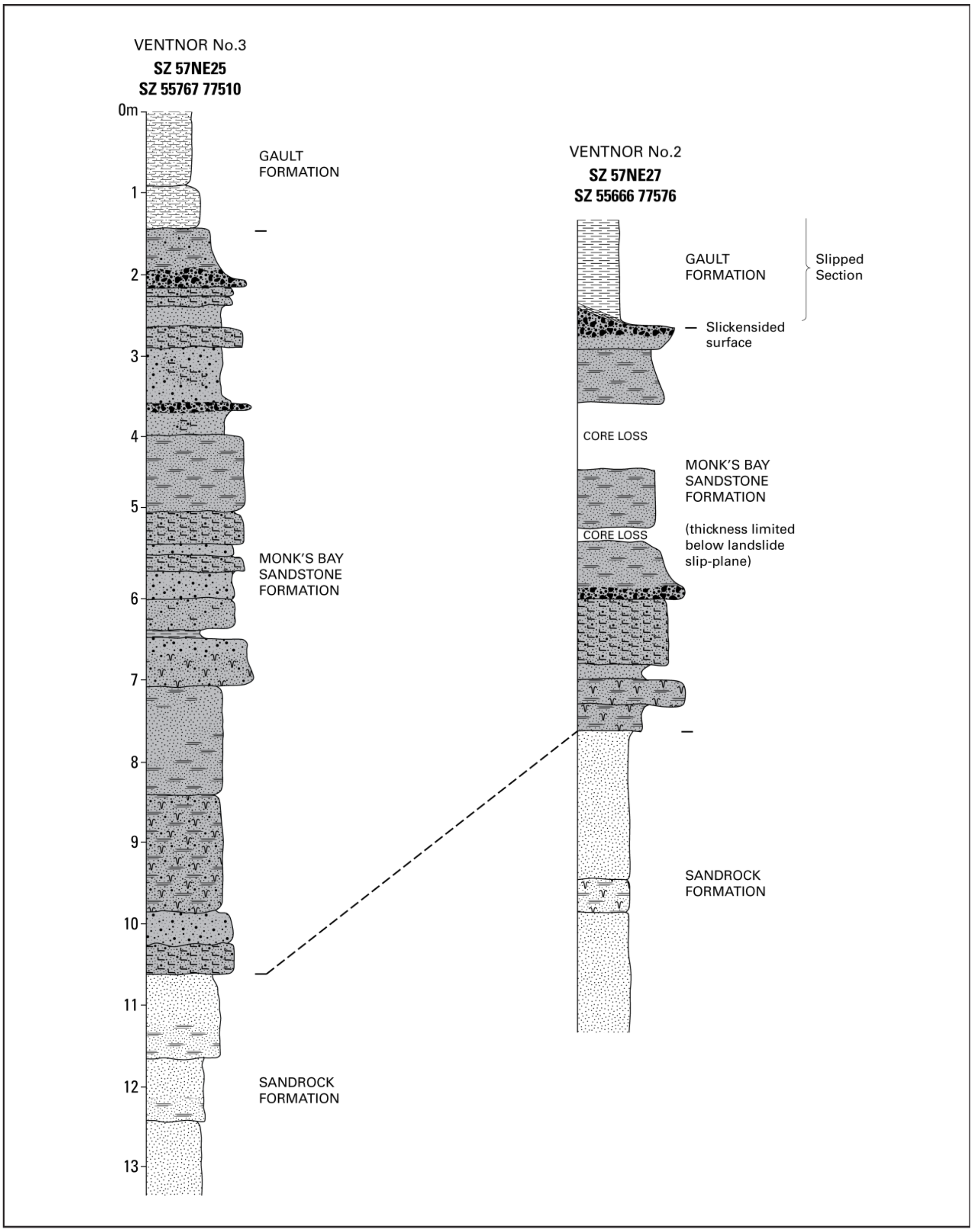
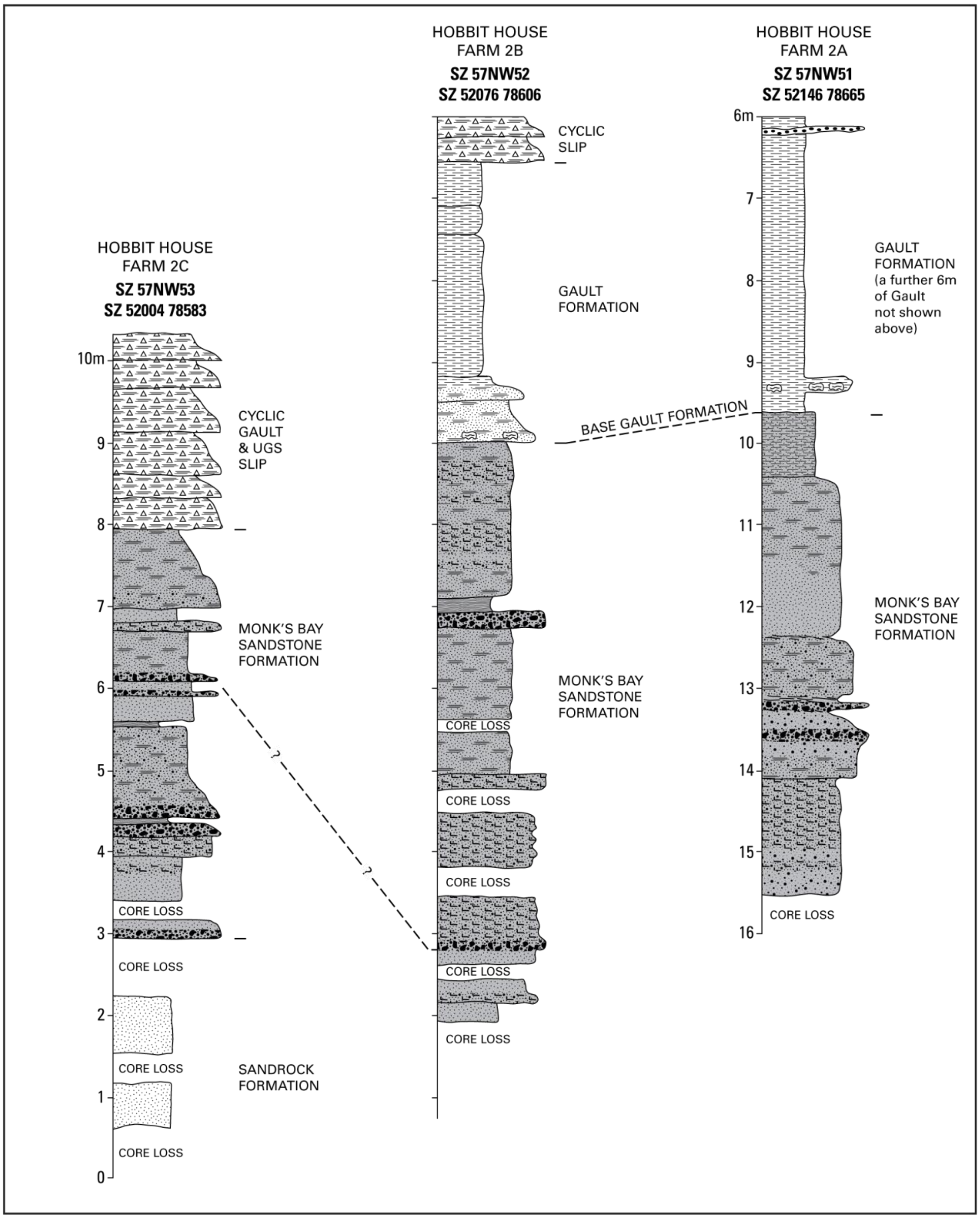

VENTNOR No.3
SZ 57NE25
SZ 55767 77510
0m
1
2
3
4
5
6
7
8
9
10
11
12
13
GAULT FORMATION
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
VENTNOR No.2
SZ 57NE27
SZ 55666 77576
GAULT FORMATION
Slipped Section
Slickensided surface
CORE LOSS
MONK'S BAY SANDSTONE FORMATION
CORE LOSS
(thickness limited below landslide slip-plane)
SANDROCK FORMATION

Fig. 12



HOBBIT HOUSE FARM 2C
SZ 57NW53
SZ 52004 78583
HOBBIT HOUSE FARM 2B
SZ 57NW52
SZ 52076 78606
HOBBIT HOUSE FARM 2A
SZ 57NW51
SZ 52146 78665
CYCLIC GAULT & UGS SLIP
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
CORE LOSS
CYCLIC SLIP
GAULT FORMATION
BASE GAULT FORMATION
GAULT FORMATION (a further 6m of Gault not shown above)
10m
6m

Fig. 13

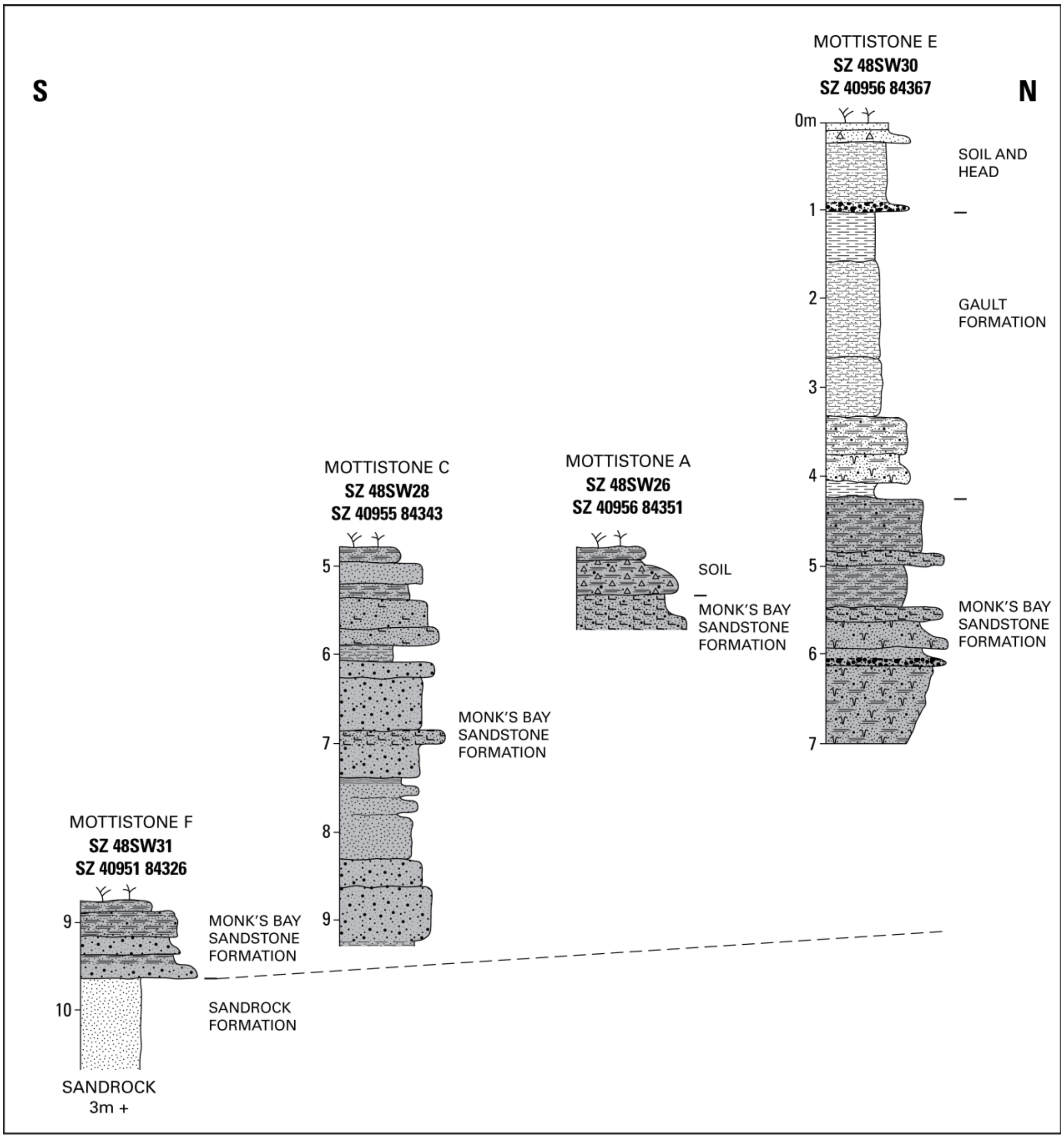

S
N
MOTTISTONE E
SZ 48SW30
SZ 40956 84367
SOIL AND HEAD
GAULT FORMATION
MONK'S BAY SANDSTONE FORMATION
MOTTISTONE C
SZ 48SW28
SZ 40955 84343
MONK'S BAY SANDSTONE FORMATION
MOTTISTONE A
SZ 48SW26
SZ 40956 84351
SOIL
MONK'S BAY SANDSTONE FORMATION
MOTTISTONE F
SZ 48SW31
SZ 40951 84326
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
SANDROCK
3m +

Fig. 14

Fig. 15

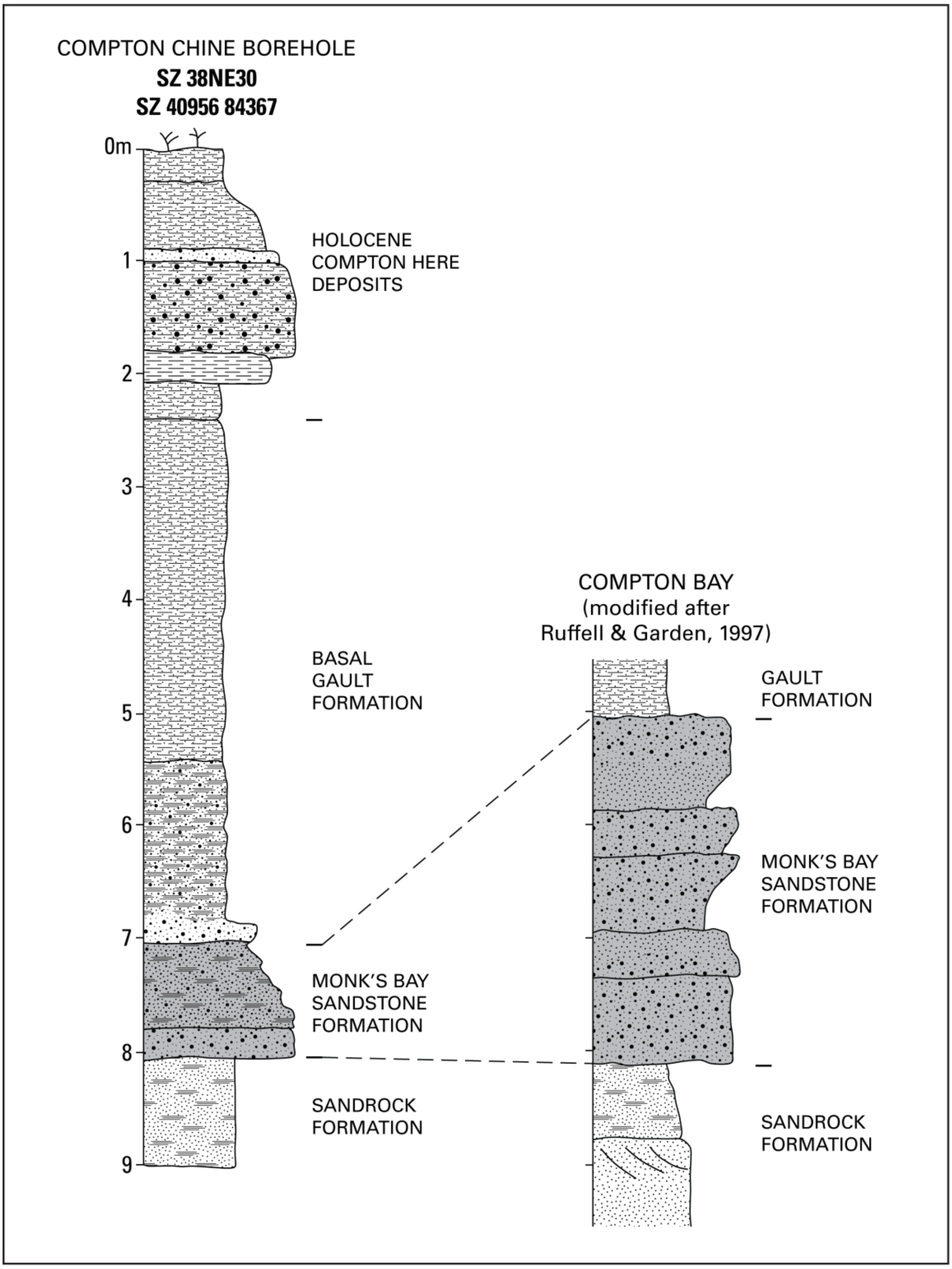
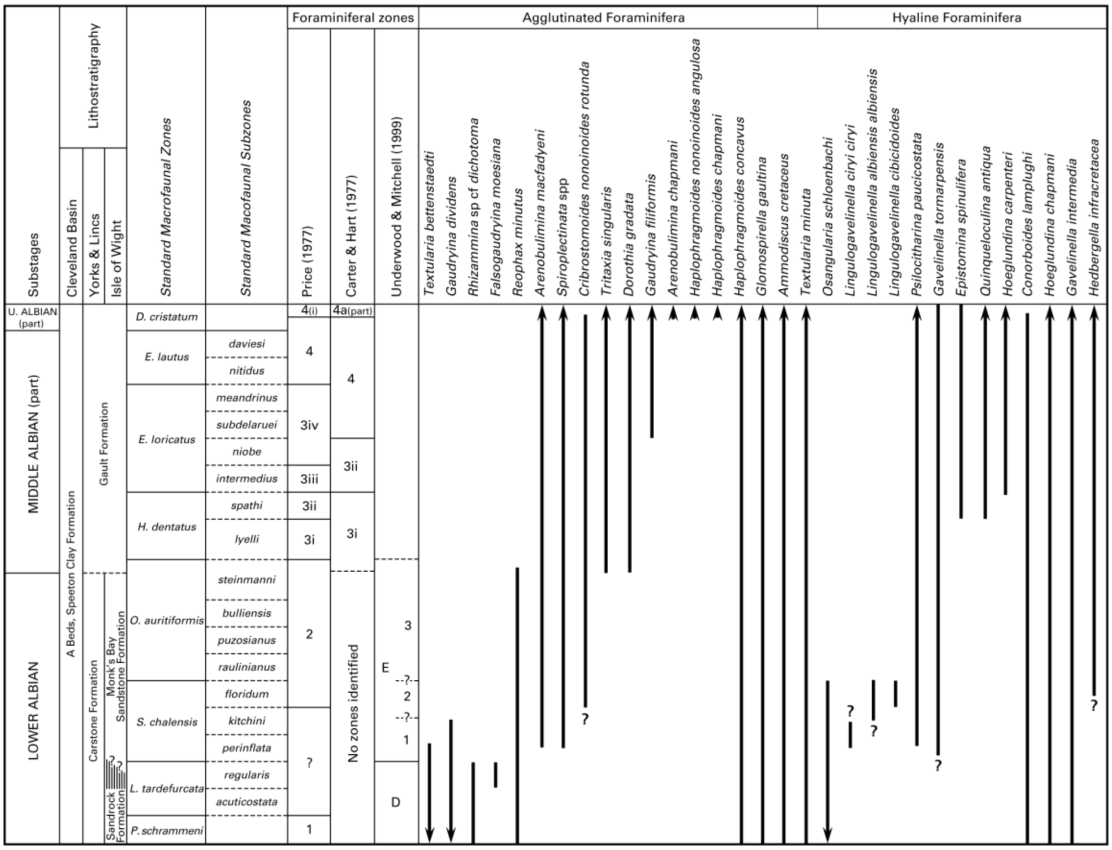

COMPTON CHINE BOREHOLE
SZ 38NE30
SZ 40956 84367
0m
1
2
3
4
5
6
7
8
9
HOLOCENE
COMPTON HERE
DEPOSITS
BASAL
GAULT
FORMATION
MONK'S BAY
SANDSTONE
FORMATION
SANDROCK
FORMATION
COMPTON BAY
(modified after
Ruffell & Garden, 1997)
GAULT
FORMATION
MONK'S BAY
SANDSTONE
FORMATION
SANDROCK
FORMATION

Fig. 16

Casey 1961; Owen 1971[a&b], 1975			Isle of Wight	Owen, 1999, 2007			
Stage	Zone	Subzone		Subzone	Zone	Superzone	Stage
Mid Albian	*Euhoplites lautus* (pars)	*Euhoplites nitidus*	**Gault Formation**	*Euhoplites nitidus*	*Euhoplites lautus* (pars)		Mid Albian
	Euhoplites loricatus	*Euhoplites meandrinus*		*Euhoplites meandrinus*	*Euhoplites loricatus*		
		Mojsisovicsia subdelaruei		*Mojsisovicsia subdelaruei*			
		Dimorphoplites niobe		*Dimorphoplites niobe*			
		Anahoplites intermedius		*Anahoplites intermedius*			
	Hoplites (Hoplites) dentatus	*Hoplites (Hoplites) spathi*		*Hoplites spathi*	*Hoplites dentatus*		
		Lyelliceras lyelli		*Lyelliceras lyelli*			
		Hoplites (Isohoplites) eondentatus	**Monk's Bay Sandstone Formation**	*Psuedosonneratia (Isohoplites) steinmanni*	*Otohoplites auritiformis*	*Douvilleiceras mammillatum*	Early Albian
Early Albian	*Douvilleiceras mammillatum*	Equivalent of *bulliensis* Subzone not proven in IoW		*Otohoplites bulliensis*			
		Protohoplites (Hemisonneratia) puzosianus		*Protohoplites (Hemisonneratia) puzosianus*			
		Otohoplites raulianus		*Otohoplites raulianus*			
		Cleoniceras floridum		*Cleoniceras floridum*	*Sonneratia chalensis*		
		Sonneratia kitchini		*Sonneratia kitchini*			
			absent	*Sonneratia (Globosonneratia) perinflatum*			
	Leymeriella (Leymeriella) tardefurcata	*Leymeriella regularis*		*Leymeriella regularis*	*Leymeriella tardefurcata*		
		Hypacanthhoplites milletioides[1]	**Sandrock Formation**	*Leymeriella acuticostata*			
		Equivalent of the *schrammeni* Zone not proven			*Proleymeriella schrammeni*[2]		

Fig. 17


Foraminiferal zones
Agglutinated Foraminifera
Hyaline Foraminifera
Substages
Lithostratigraphy
Cleveland Basin
Yorks & Lincs
Isle of Wight
Standard Macrofaunal Zones
Standard Macofaunal Subzones
Price (1977)
Carter & Hart (1977)
Underwood & Mitchell (1999)
Textularia bettenstaedti
Gaudryina dividens
Rhizammina sp cf dichotoma
Falsogaudryina moesiana
Reophax minutus
Arenobulimina macfadyeni
Spiroplectinata spp
Cribrostomoides nonoinoides rotunda
Tritaxia singularis
Dorothia gradata
Gaudryina filiformis
Arenobulimina chapmani
Haplophragmoides nonoinoides angulosa
Haplophragmoides chapmani
Haplophragmoides concavus
Glomospirella gaultina
Ammodiscus cretaceus
Textularia minuta
Osangularia schloenbachi
Lingulogavelinella ciryi ciryi
Lingulogavelinella albiensis albiensis
Lingulogavelinella cibicidoides
Psilocitharina paucicostata
Gavelinella tormarpensis
Epistomina spinulifera
Quinqueloculina antiqua
Hoeglundina carpenteri
Conorboides lamplughi
Hoeglundina chapmani
Gavelinella intermedia
Hedbergella infracretacea
U. ALBIAN (part)
MIDDLE ALBIAN (part)
LOWER ALBIAN
A Beds, Speeton Clay Formation
Gault Formation
Carstone Formation
Monk's Bay Sandstone Formation
Sandrock Formation
D. cristatum
E. lautus
E. loricatus
H. dentatus
O. auritiformis
S. chalensis
L. tardefurcata
P. schrammeni
daviesi
nitidus
meandrinus
subdelaruei
niobe
intermedius
spathi
lyelli
steinmanni
bulliensis
puzosianus
raulinianus
floridum
kitchini
perinflata
regularis
acuticostata
4(i)
4
3iv
3iii
3ii
3i
2
?
1
4a(part)
4
3ii
3i
No zones identified
3
E
2
1
D

Table

Monks Bay Sandstone Tables File

<table>
<tr><th>Group</th><th>Formation</th><th>Stage</th></tr>
<tr><td rowspan="2">Selborne</td><td>Upper Greensand</td><td rowspan="4">Albian</td></tr>
<tr><td>Gault</td></tr>
<tr><td rowspan="4">Lower Greensand</td><td>Monk’s Bay Sandstone</td></tr>
<tr><td>Sandrock</td></tr>
<tr><td>Ferruginous Sands</td><td rowspan="2">Aptian</td></tr>
<tr><td>Atherfield Clay</td></tr>
</table>

Table 1. Simplified litho- and chrono-stratigraphy of part of the Lower Cretaceous of the Isle of Wight.

Location	Grid Reference
Rock	SZ 4251 8397
Marvel Wood	SZ 4988 8690
Billingham Cottages	SZ 4831 8244
Birchmore	SZ 5062 8529
Whitecroft	SZ 4989 8631
Knighton Brook	SZ 5677 8676
Itchall	SZ 5198 7930
Itchall	SZ 5219 7961

Table 2. Additional locations described in White (1921) for the Monk’s Bay Sandstone Formation.

Location	Locality Grid Reference	Registered Number(s)
Knighton Sand Pit	SZ 575 867	SZ58NE 98 to 100
Whitwell (Hobbit House Farm)	SZ 520 786	SZ57NW 51 to 53
Mottistone	SZ 408 843	SZ48SW 26 to 31
Compton Chine	SZ 368 852	SZ38NE 30
Ventnor*	SZ 557 775	SZ57NE 27 and 25

Table 3. The BGS boreholes described in this paper.

Figure

Monks Bay Sandstone Figures File

List of Figures

Fig. 7a. The lower part of the exposure of Monks Bay Sandstone Formation exposed in the Knighton Sand Pit [SZ 57474 86712]. At this locality the formation rests with a sharp erosive contact (arrowed) (hoe head 0.6 m long) on laminated/finely-bedded sandy clayey silts at the top of the the Sandrock Formation. BGS image P683907.

Fig. 7b. The upper part of the Monk's Bay Sandstone Formation at the Knighton Sand Pit (hammer 0.28 m). BGS image P683932.

Fig. 8. Marvel Sand Pit [SZ 4992 8687]. Boundary (arrowed), between the Sandrock Formation and the Monks Bay Sandstone Formation, just below ferruginous ironstone band. Field of view approx 40 x 55 m. BGS image P 692204.

Fig. 9. Graphic log for Rookley Brickworks [SZ 5133 8395] modified after Dike (1972). See Fig. 3b for key.

Fig. 10. The contact (arrowed) of the Sandrock Formation and the Monk's Bay Sandstone Formation in the cliff adjacent to Luccombe Chine [SZ 58325 79278], Isle of Wight. BGS image P732232.

Fig. 11. Graphic borehole log for The Monk's Bay Sandstone Formation and adjacent units from the Ventnor No. 2 and 3 boreholes. See Fig. 3b for key.

Fig. 12. Graphic log, as a composite of the three boreholes completed at Hobbit House Farm, Whitwell. See Fig. 3b for key.

Fig. 13. Correlation of the four boreholes at Mottistone. See Fig. 3b for key.

Fig. 14. Compton Bay. The attenuated Monk's Bay Sandstone Formation, 1.83 m thick, exposed at beach level adjacent to Compton Chine. Dark glauconitic sandy mudstone of the Sandrock Formation is visible below and dark grey basal sandy mudstone of the Gault Formation above. [SZ 436736 085214]. Hammer 28 cm. BGS image P732435.

Fig. 15. Graphic log of the Monk's Bay Sandstone at Compton Chine borehole compared to that from Compton Bay (Ruffell and Garden, 1997). See Fig. 3b for key.

Fig. 16. The ammonite zonal scheme adopted by Casey (1961) and others for the Early and Mid Albian of the UK, compared to that of Owen (1999, 2007). 1. *Leymeriella acuticosta* in Europe; 2. *Farnhamia farnhamensis* is synonymn of *Proleymeriella schrammeni* (e.g. Mutterlose et al. 2003).

Fig. 17 The lithostratigraphy of the Lower and Middle Albian of southern and eastern England related to the ammonite zones/subzones (Casey 1961, Owen 1999). Shaded area depicts the erosional gap in the succession, which Casey (1961) considered to occupy the entire *L. regularis* Zone. Ranges of selected Early Albian foraminifera and the foraminiferal zonation are correlated to ammonite biostratigraphy (not the lithostratigraphy).

Fig 1.

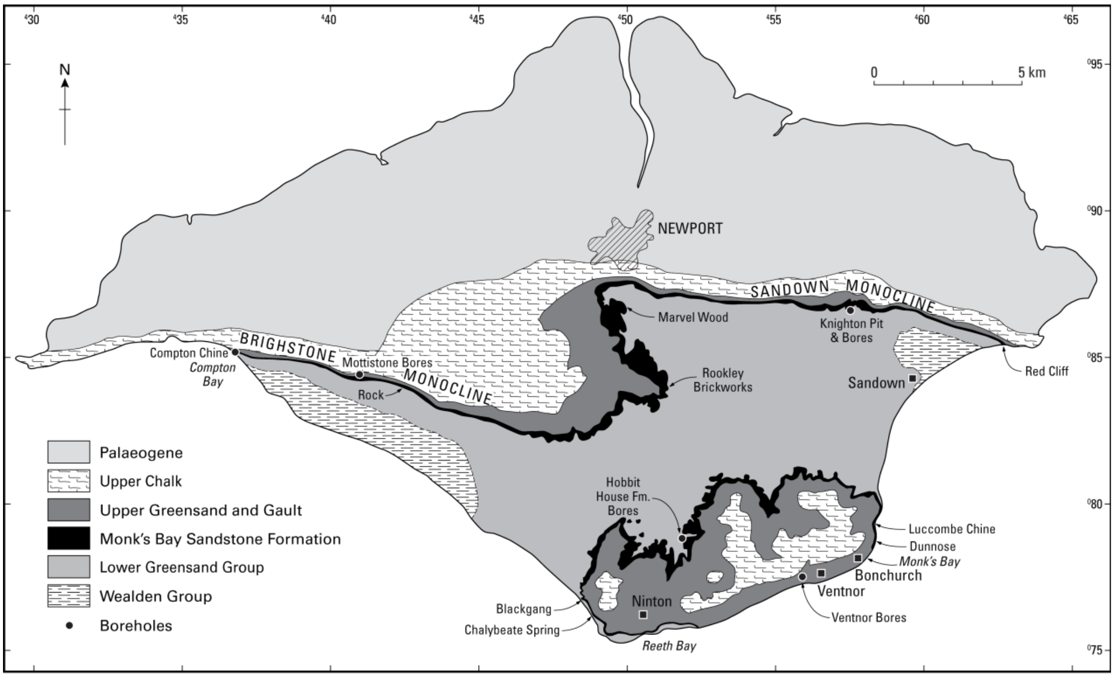
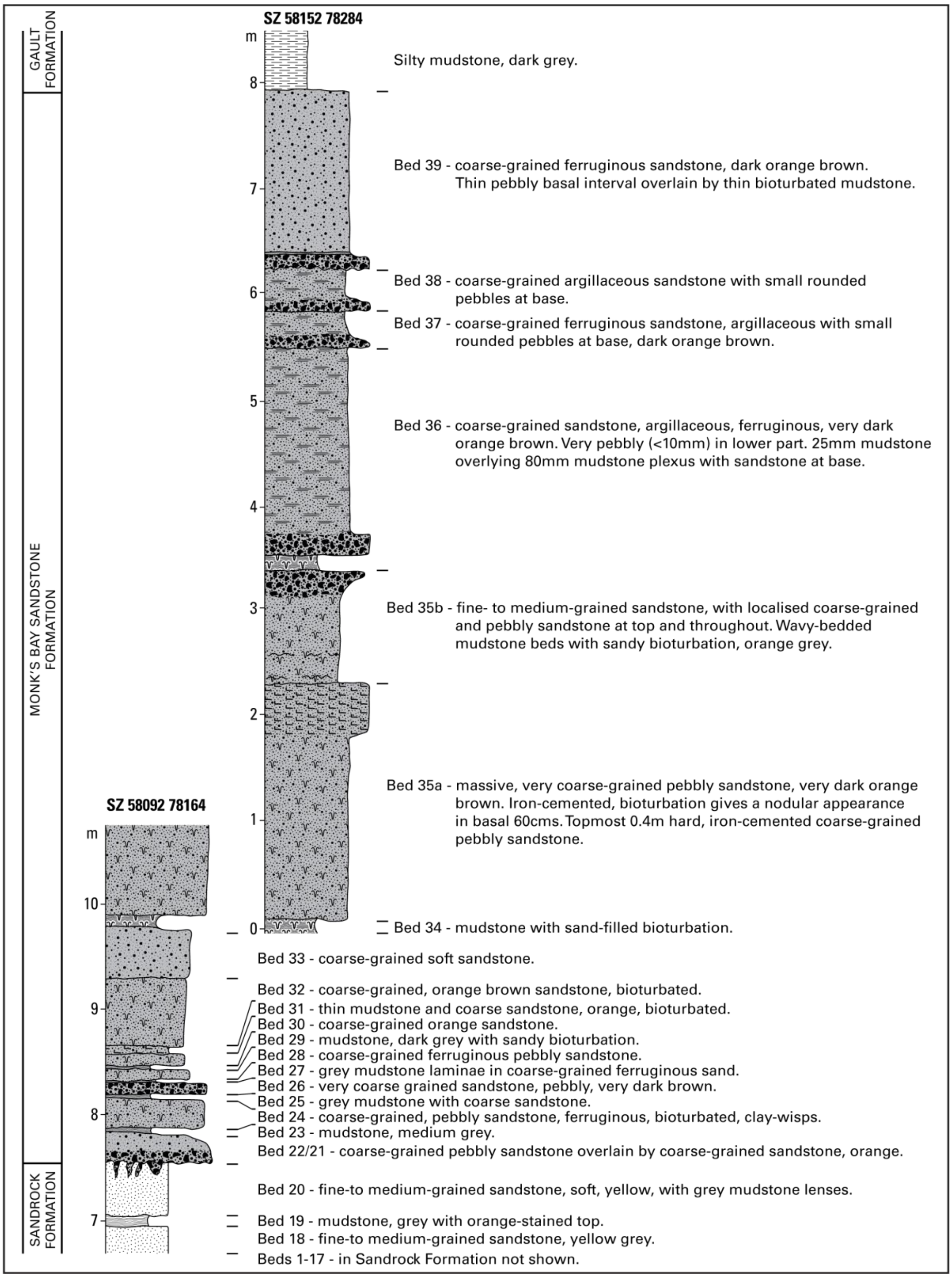


Fig. 2

Fig. 3a



GAULT FORMATION
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
SZ 58152 78284
m
8
7
6
5
4
3
2
1
0
Silty mudstone, dark grey.
Bed 39 - coarse-grained ferruginous sandstone, dark orange brown. Thin pebbly basal interval overlain by thin bioturbated mudstone.
Bed 38 - coarse-grained argillaceous sandstone with small rounded pebbles at base.
Bed 37 - coarse-grained ferruginous sandstone, argillaceous with small rounded pebbles at base, dark orange brown.
Bed 36 - coarse-grained sandstone, argillaceous, ferruginous, very dark orange brown. Very pebbly (<10mm) in lower part. 25mm mudstone overlying 80mm mudstone plexus with sandstone at base.
Bed 35b - fine- to medium-grained sandstone, with localised coarse-grained and pebbly sandstone at top and throughout. Wavy-bedded mudstone beds with sandy bioturbation, orange grey.
Bed 35a - massive, very coarse-grained pebbly sandstone, very dark orange brown. Iron-cemented, bioturbation gives a nodular appearance in basal 60cms. Topmost 0.4m hard, iron-cemented coarse-grained pebbly sandstone.
SZ 58092 78164
m
10
9
8
7
Bed 34 - mudstone with sand-filled bioturbation.
Bed 33 - coarse-grained soft sandstone.
Bed 32 - coarse-grained, orange brown sandstone, bioturbated.
Bed 31 - thin mudstone and coarse sandstone, orange, bioturbated.
Bed 30 - coarse-grained orange sandstone.
Bed 29 - mudstone, dark grey with sandy bioturbation.
Bed 28 - coarse-grained ferruginous pebbly sandstone.
Bed 27 - grey mudstone laminae in coarse-grained ferruginous sand.
Bed 26 - very coarse grained sandstone, pebbly, very dark brown.
Bed 25 - grey mudstone with coarse sandstone.
Bed 24 - coarse-grained, pebbly sandstone, ferruginous, bioturbated, clay-wisps.
Bed 23 - mudstone, medium grey.
Bed 22/21 - coarse-grained pebbly sandstone overlain by coarse-grained sandstone, orange.
Bed 20 - fine-to medium-grained sandstone, soft, yellow, with grey mudstone lenses.
Bed 19 - mudstone, grey with orange-stained top.
Bed 18 - fine-to medium-grained sandstone, yellow grey.
Beds 1-17 - in Sandrock Formation not shown.

Fig. 3b

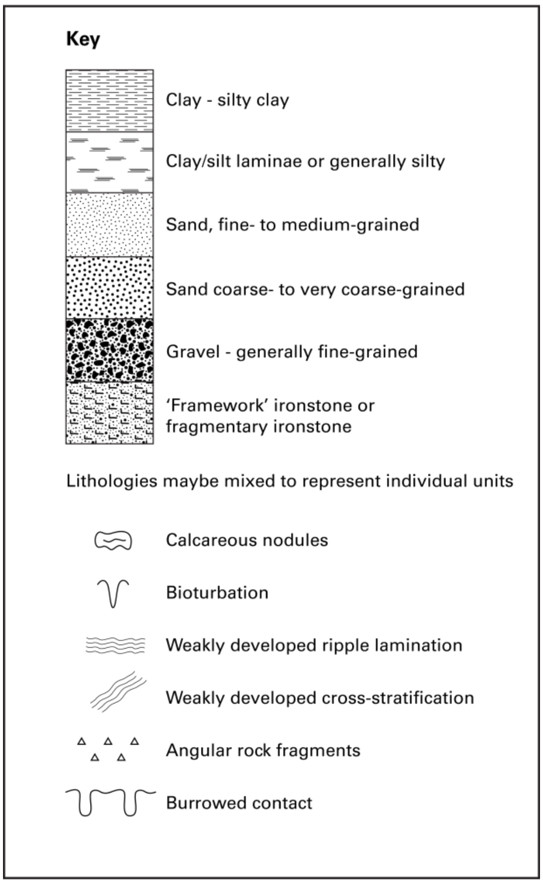

Key
Clay - silty clay
Clay/silt laminae or generally silty
Sand, fine- to medium-grained
Sand coarse- to very coarse-grained
Gravel - generally fine-grained
'Framework' ironstone or fragmentary ironstone
Lithologies maybe mixed to represent individual units
Calcareous nodules
Bioturbation
Weakly developed ripple lamination
Weakly developed cross-stratification
Angular rock fragments
Burrowed contact

Fig. 4

Fig. 5

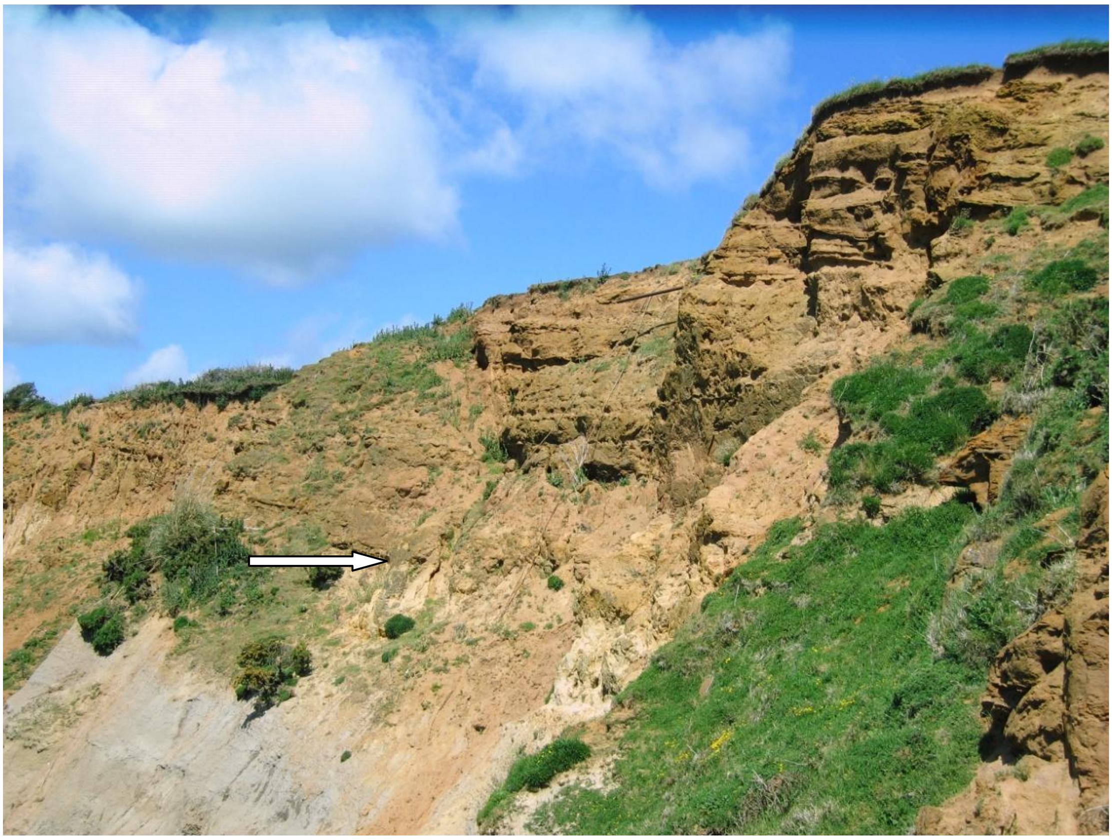


Fig. 6

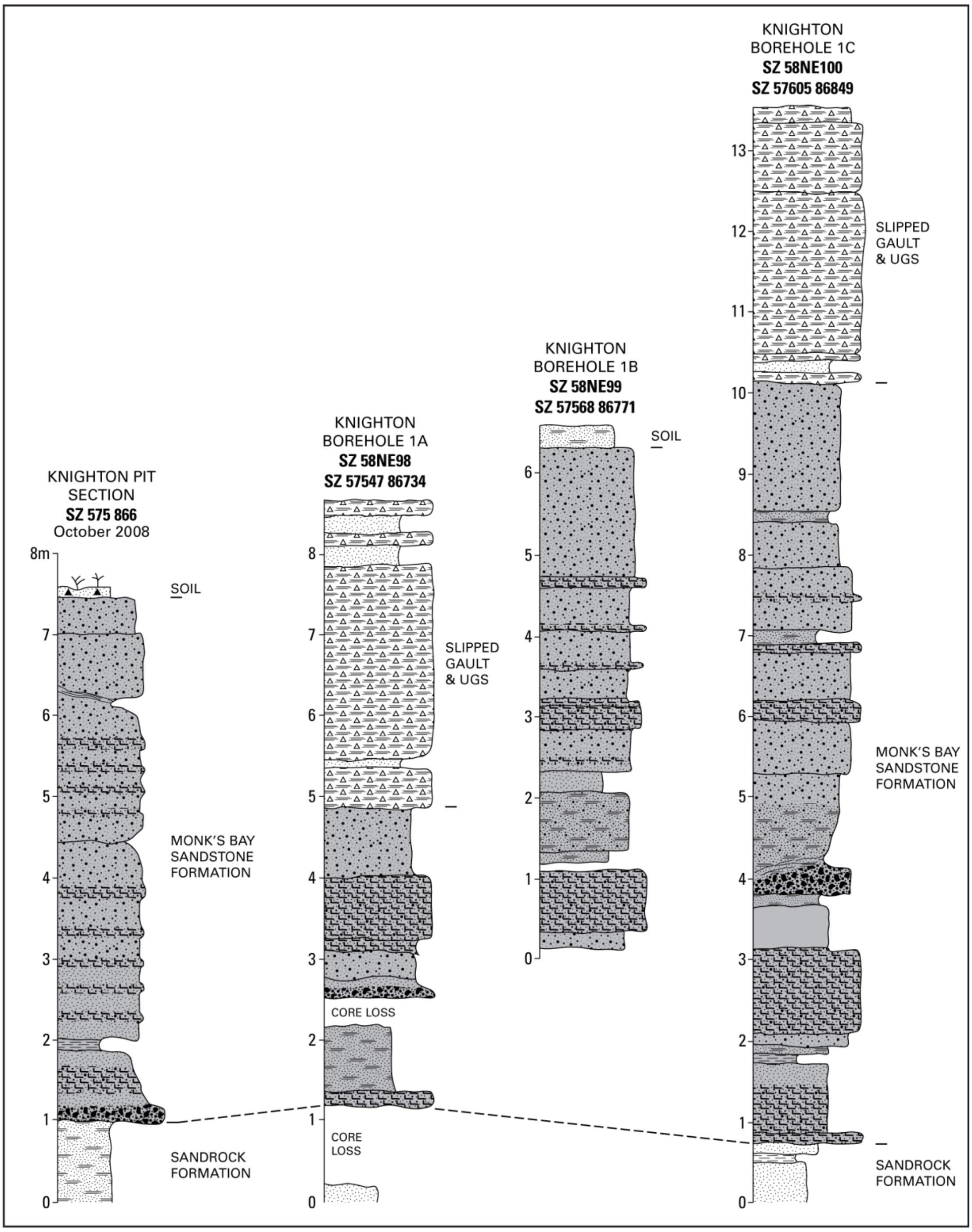

KNIGHTON PIT SECTION
SZ 575 866
October 2008
KNIGHTON BOREHOLE 1A
SZ 58NE98
SZ 57547 86734
KNIGHTON BOREHOLE 1B
SZ 58NE99
SZ 57568 86771
KNIGHTON BOREHOLE 1C
SZ 58NE100
SZ 57605 86849
8m
SOIL
SLIPPED GAULT & UGS
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
CORE LOSS
0
1
2
3
4
5
6
7
8
9
10
11
12
13

Fig. 7a

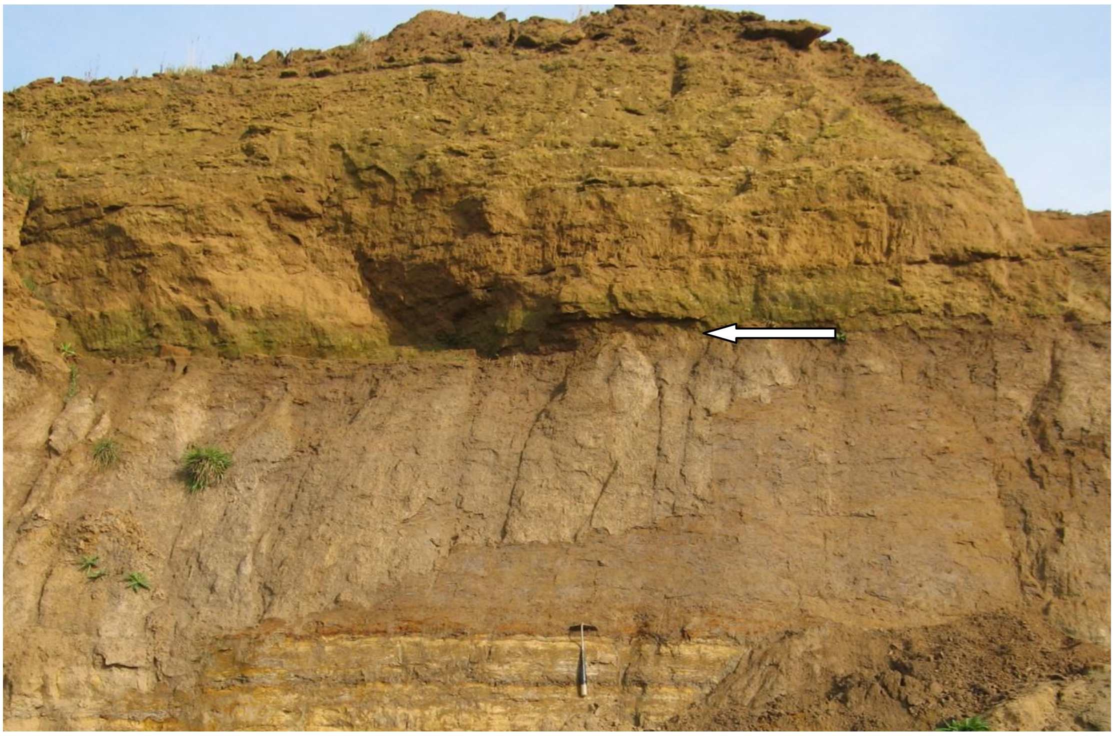


Fig. 7b

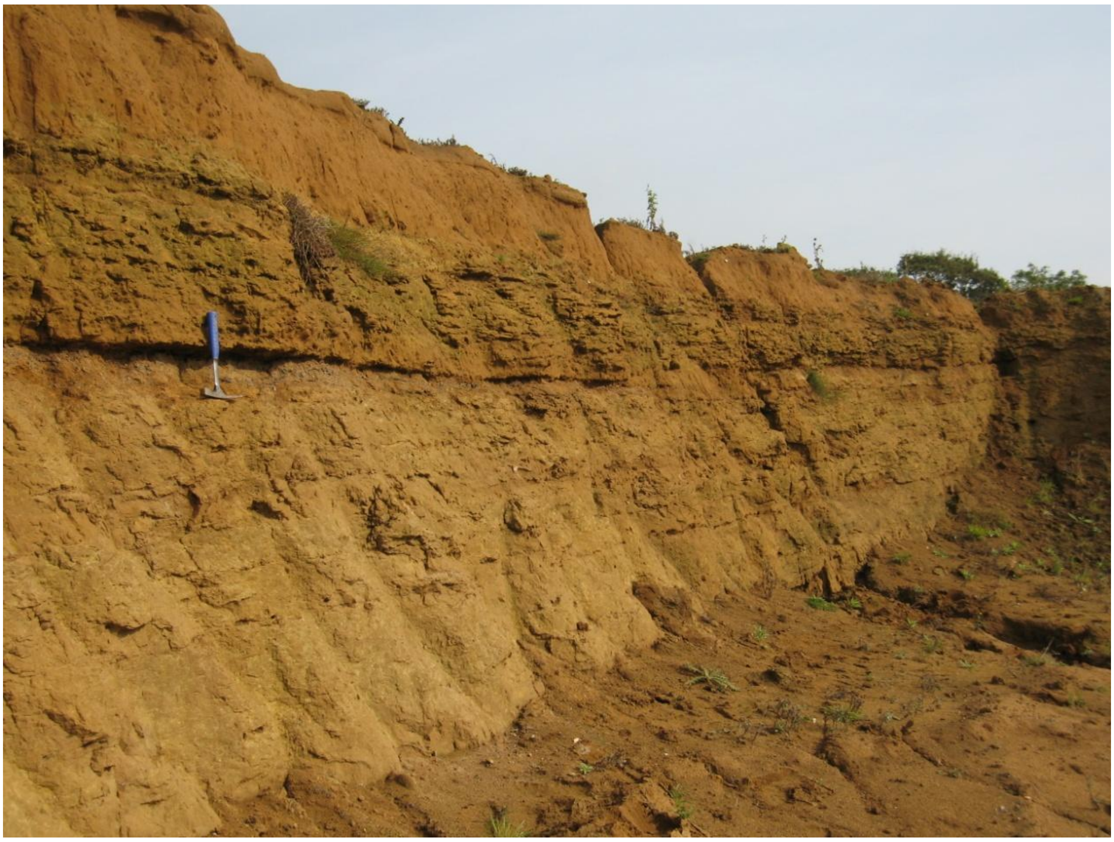


Fig. 8

Fig. 9

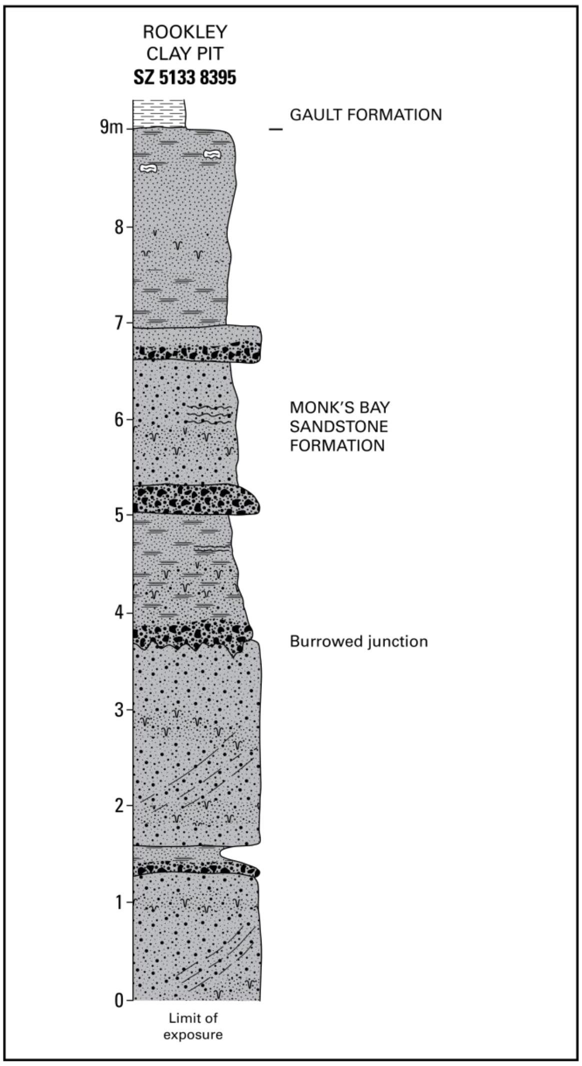
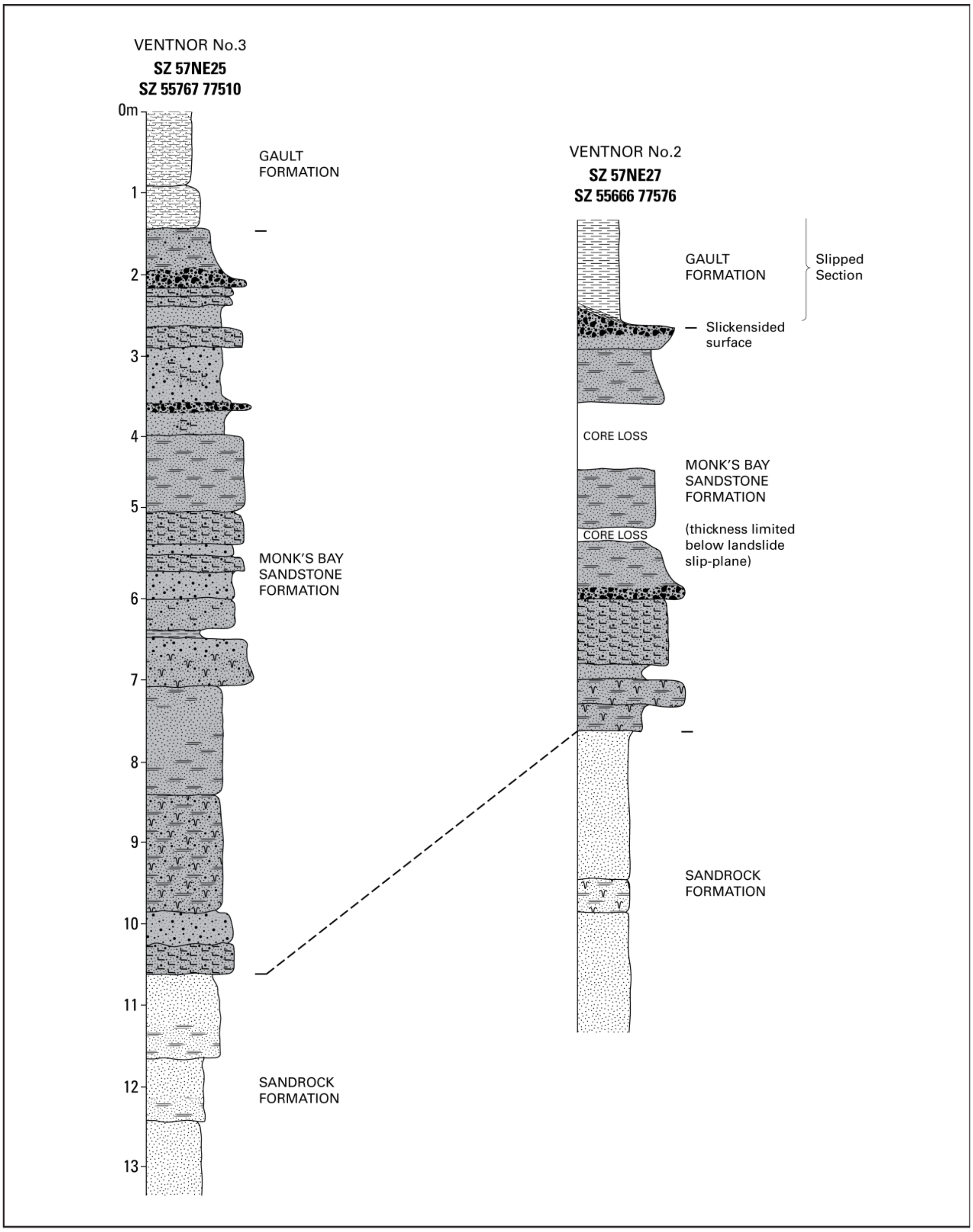

ROOKLEY
CLAY PIT
SZ 5133 8395
9m
8
7
6
5
4
3
2
1
0
GAULT FORMATION
MONK'S BAY
SANDSTONE
FORMATION
Burrowed junction
Limit of
exposure

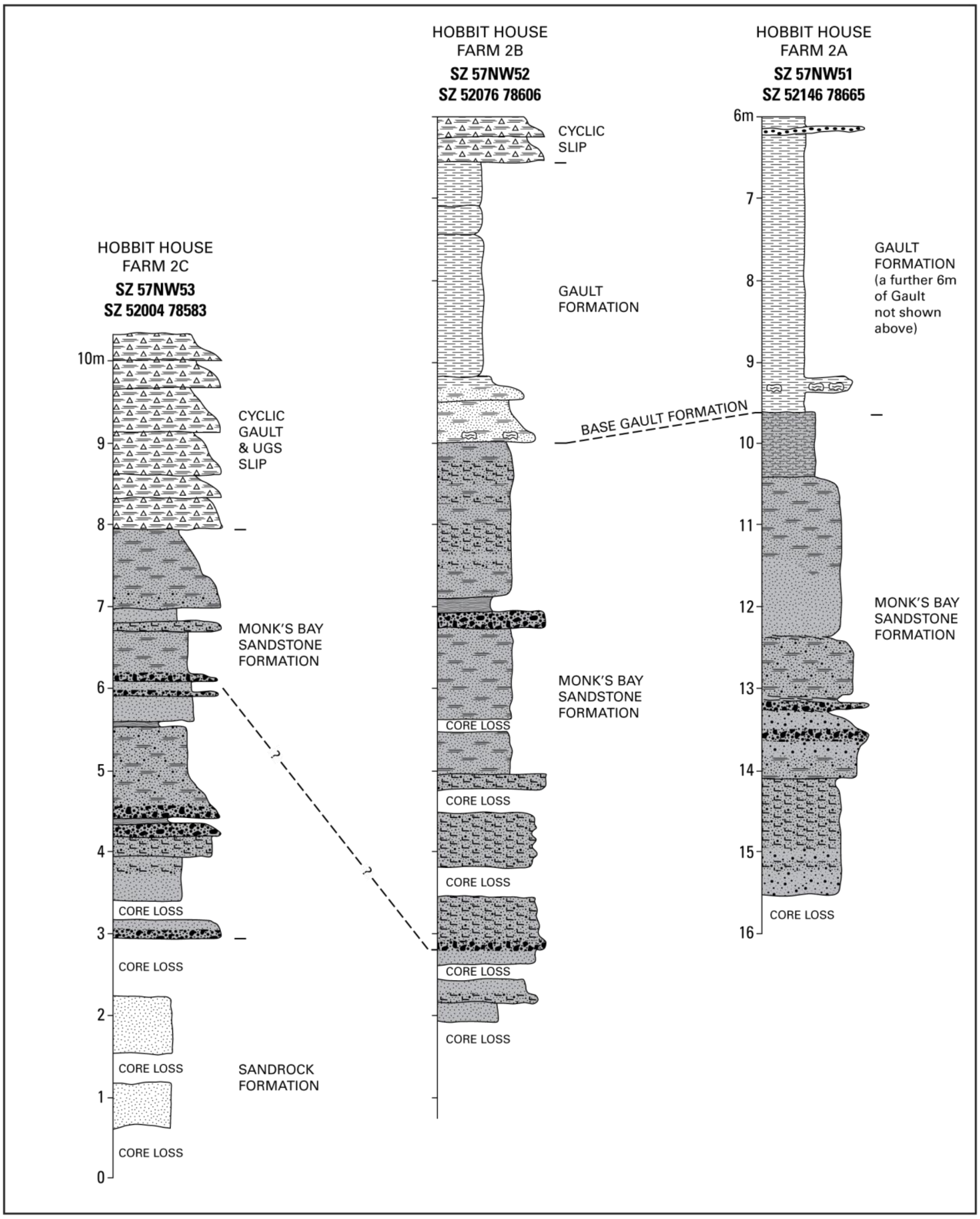
Fig. 10

Fig. 11



VENTNOR No.3
SZ 57NE25
SZ 55767 77510
0m
1
2
3
4
5
6
7
8
9
10
11
12
13
GAULT FORMATION
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
VENTNOR No.2
SZ 57NE27
SZ 55666 77576
GAULT FORMATION
Slipped Section
Slickensided surface
CORE LOSS
MONK'S BAY SANDSTONE FORMATION
CORE LOSS
(thickness limited below landslide slip-plane)
SANDROCK FORMATION

Fig. 12



HOBBIT HOUSE FARM 2C
SZ 57NW53
SZ 52004 78583
HOBBIT HOUSE FARM 2B
SZ 57NW52
SZ 52076 78606
HOBBIT HOUSE FARM 2A
SZ 57NW51
SZ 52146 78665
CYCLIC GAULT & UGS SLIP
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
CORE LOSS
CYCLIC SLIP
GAULT FORMATION
BASE GAULT FORMATION
GAULT FORMATION (a further 6m of Gault not shown above)
10m
6m

Fig. 13

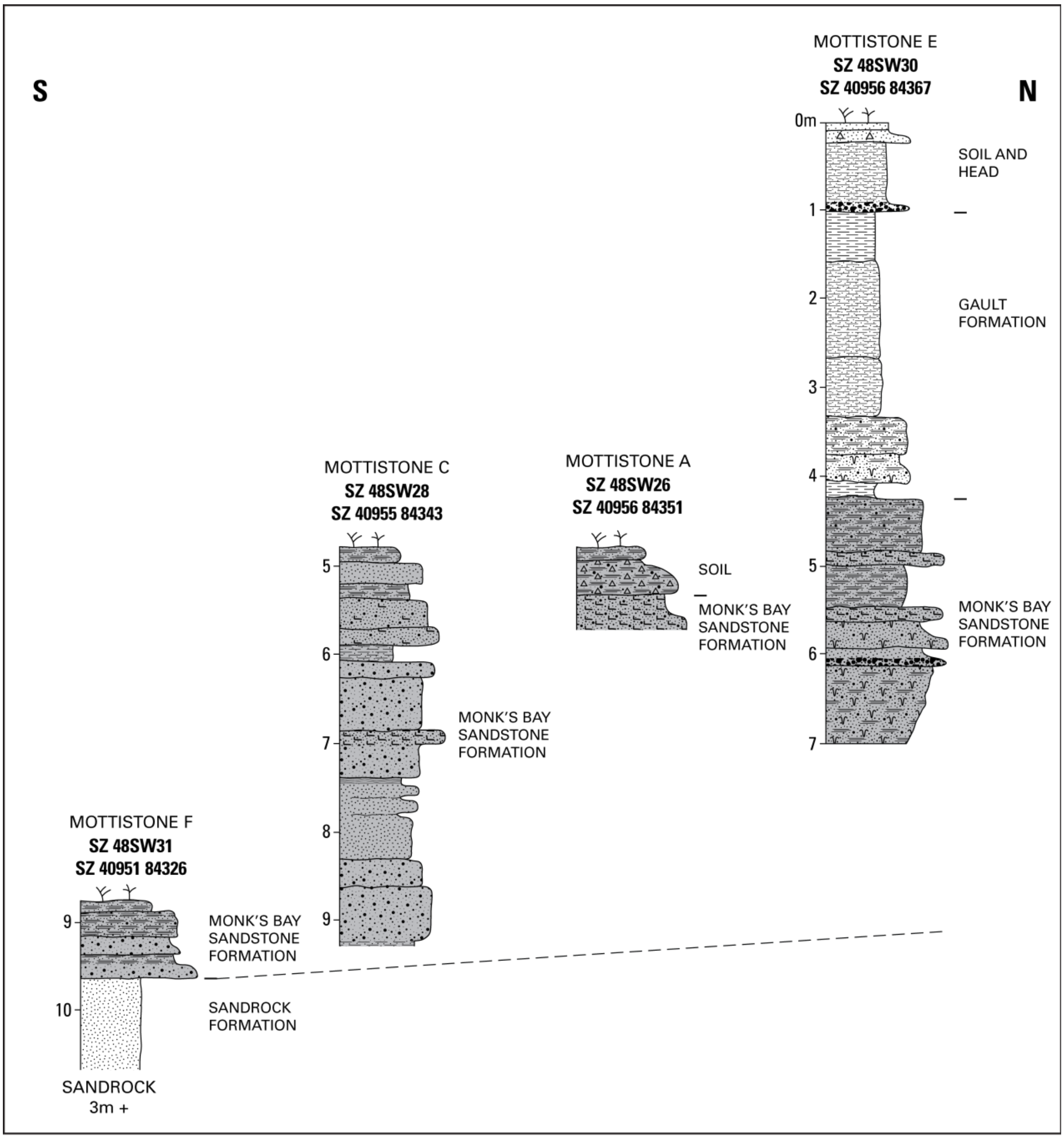

S
N
MOTTISTONE E
SZ 48SW30
SZ 40956 84367
0m
1
2
3
4
5
6
7
SOIL AND HEAD
GAULT FORMATION
MONK'S BAY SANDSTONE FORMATION
MOTTISTONE C
SZ 48SW28
SZ 40955 84343
5
6
7
8
9
MONK'S BAY SANDSTONE FORMATION
MOTTISTONE A
SZ 48SW26
SZ 40956 84351
SOIL
MONK'S BAY SANDSTONE FORMATION
MOTTISTONE F
SZ 48SW31
SZ 40951 84326
9
10
MONK'S BAY SANDSTONE FORMATION
SANDROCK FORMATION
SANDROCK
3m +

Fig. 14

Fig 15

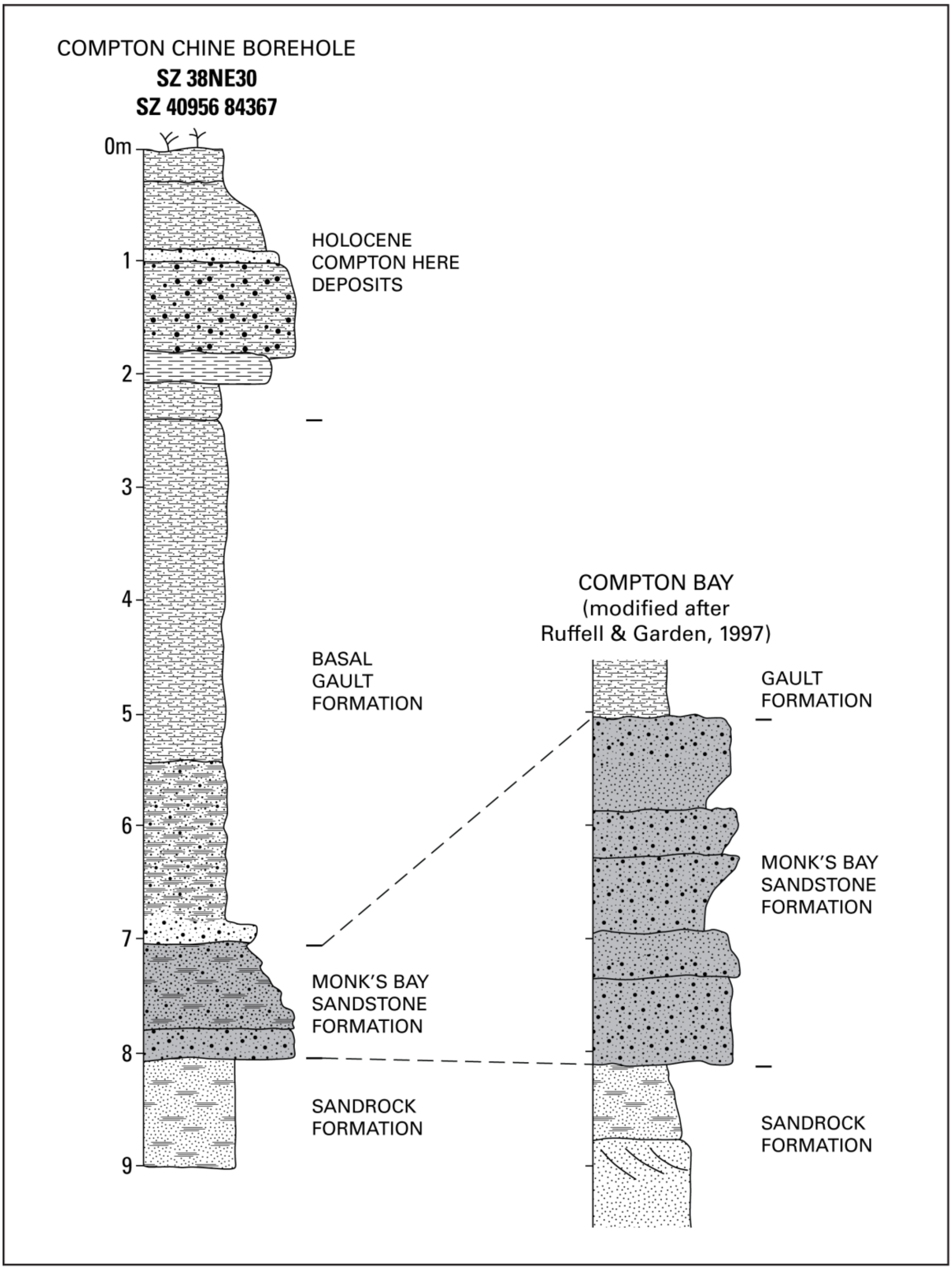
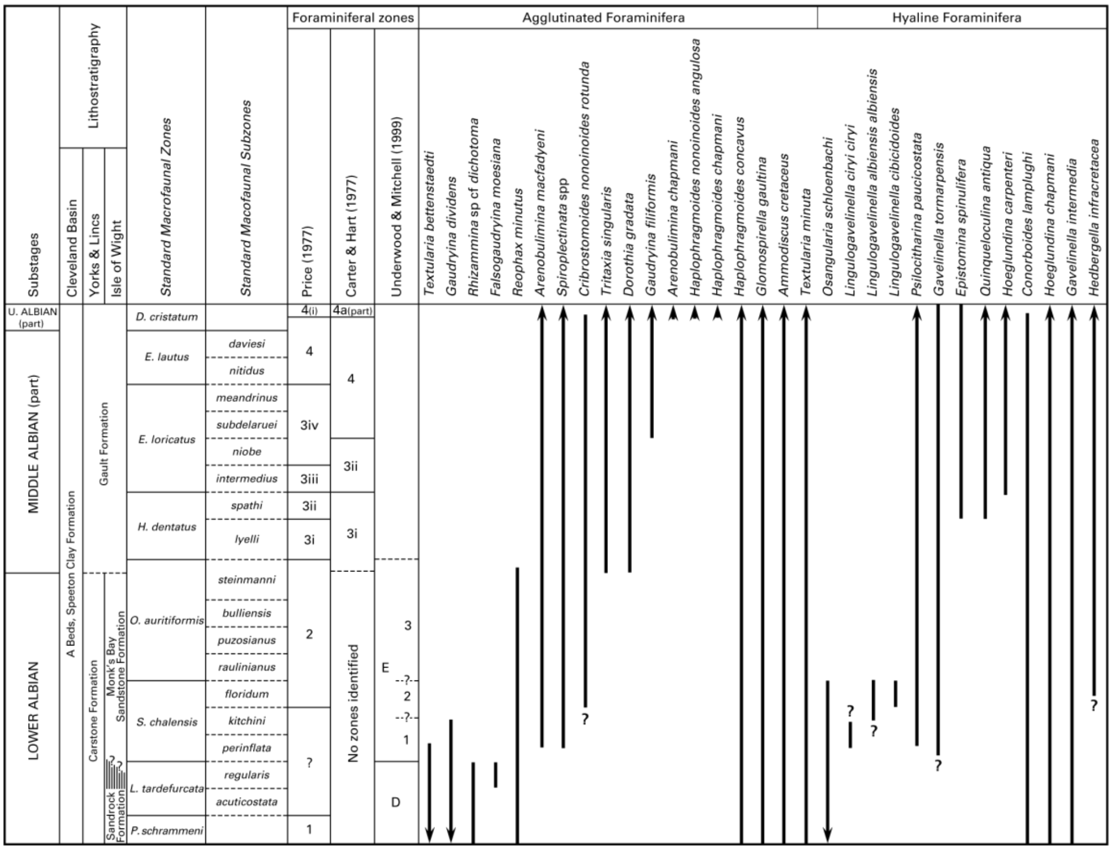

COMPTON CHINE BOREHOLE
SZ 38NE30
SZ 40956 84367
0m
1
2
3
4
5
6
7
8
9
HOLOCENE
COMPTON HERE
DEPOSITS
BASAL
GAULT
FORMATION
MONK'S BAY
SANDSTONE
FORMATION
SANDROCK
FORMATION
COMPTON BAY
(modified after
Ruffell & Garden, 1997)
GAULT
FORMATION
MONK'S BAY
SANDSTONE
FORMATION
SANDROCK
FORMATION

Fig. 16

Casey 1961; Owen 1971[a&b], 1975			Isle of Wight	Owen, 1999, 2007			
Stage	Zone	Subzone		Subzone	Zone	Superzone	Stage
Mid Albian	*Euhoplites lautus* (pars)	*Euhoplites nitidus*	**Gault Formation**	*Euhoplites nitidus*	*Euhoplites lautus* (pars)		Mid Albian
	Euhoplites loricatus	*Euhoplites meandrinus*		*Euhoplites meandrinus*	*Euhoplites loricatus*		
		Mojsisovicsia subdelaruei		*Mojsisovicsia subdelaruei*			
		Dimorphoplites niobe		*Dimorphoplites niobe*			
		Anahoplites intermedius		*Anahoplites intermedius*			
	Hoplites (Hoplites) dentatus	*Hoplites (Hoplites) spathi*		*Hoplites spathi*	*Hoplites dentatus*		
		Lyelliceras lyelli		*Lyelliceras lyelli*			
		Hoplites (Isohoplites) eondentatus	**Monk's Bay Sandstone Formation**	*Psuedosonneratia (Isohoplites) steinmanni*	*Otohoplites auritiformis*	*Douvilleiceras mammillatum*	Early Albian
Early Albian	*Douvilleiceras mammillatum*	Equivalent of *bulliensis* Subzone not proven in IoW		*Otohoplites bulliensis*			
		Protohoplites (Hemisonneratia) puzosianus		*Protohoplites (Hemisonneratia) puzosianus*			
		Otohoplites raulianus		*Otohoplites raulianus*			
		Cleoniceras floridum		*Cleoniceras floridum*	*Sonneratia chalensis*		
		Sonneratia kitchini		*Sonneratia kitchini*			
			absent	*Sonneratia (Globosonneratia) perinflatum*			
	Leymeriella (Leymeriella) tardefurcata	*Leymeriella regularis*		*Leymeriella regularis*	*Leymeriella tardefurcata*		
		Hypacanthhoplites milletioides[1]	**Sandrock Formation**	*Leymeriella acuticostata*			
		Equivalent of the *schrammeni* Zone not proven			*Proleymeriella schrammeni*[2]		

Fig 17.


Substages
Lithostratigraphy
Cleveland Basin
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Standard Macrofaunal Zones
Standard Macofaunal Subzones
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Price (1977)
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Arenobulimina chapmani
Haplophragmoides nonoinoides angulosa
Haplophragmoides chapmani
Haplophragmoides concavus
Glomospirella gaultina
Ammodiscus cretaceus
Textularia minuta
Osangularia schloenbachi
Lingulogavelinella ciryi ciryi
Lingulogavelinella albiensis albiensis
Lingulogavelinella cibicidoides
Psilocitharina paucicostata
Gavelinella tormarpensis
Epistomina spinulifera
Quinqueloculina antiqua
Hoeglundina carpenteri
Conorboides lamplughi
Hoeglundina chapmani
Gavelinella intermedia
Hedbergella infracretacea
U. ALBIAN (part)
MIDDLE ALBIAN (part)
LOWER ALBIAN
A Beds, Speeton Clay Formation
Gault Formation
Carstone Formation
Monk's Bay Sandstone Formation
Sandrock Formation
D. cristatum
E. lautus
E. loricatus
H. dentatus
O. auritiformis
S. chalensis
L. tardefurcata
P. schrammeni
daviesi
nitidus
meandrinus
subdelaruei
niobe
intermedius
spathi
lyelli
steinmanni
bulliensis
puzosianus
raulinianus
floridum
kitchini
perinflata
regularis
acuticostata
4(i)
4
3iv
3iii
3ii
3i
2
?
1
4a(part)
4
3ii
3i
No zones identified
E
3
2
1
D