# Whitecliff, Isle of Wight

[SZ 638 854]–[SZ 639 858]

## Introduction

Whitecliff, Isle of Wight, is an extraordinary site, forming a continuous north–south dip section exposing some 300 m of Chalk from the Upper Turonian Substage at 'The Nostrils' at the southern end, to the Upper Campanian Substage beneath the Palaeogene unconformity at the northern end (Figure 3.12) and (Figure 3.64). It is one of the few dip sections in the Chalk of England. The GCR site is complemented by the excellent Cenomanian and Lower Turonian sections on Culver Cliff in Sandown Bay, to the west. The Chalk dips steeply north at 70° and each bed is exposed in turn over a relatively short distance. The only access to the section is from Whitecliff Bay or by boat.

## Description

The Whitecliff section falls completely within Barrois' Craie Blanche' (White Chalk), which he subdivided into four macrofossil assemblage zones (Barrois, 1875). In Reid and Strahan's (1889) account of the geology of the Isle of Wight, the Whitecliff section is, surprisingly, not mentioned. This omission contrasts with the measured section given for the Lower and Middle Chalk in the adjacent Culver Cliff. Jukes-Browne and Hill (1904, p. 93) made only one reference to the Whitecliff section (calling it 'Culver Cliff '). They recorded an observation made by Whitaker (1865c) on the so-called 'flintless belt' with its single tabular (sheet-) flint band and four green-coated nodular beds, from which Whitaker obtained the echinoid *Offaster pilula* (Lamarck).

It was left to Rowe (1908) to provide the first full account of this wonderful section. He divided the exposures into three; the 'Southern cliff', 'Eastern cliff' and, on the northern side, his 'White Cliff proper'. However, due to the numerous cliff falls and the seaweed and algal slime-coated faces, he found measuring the section and the collection of fossils particularly difficult. Nevertheless, he recognized the zonal divisions and was the first to record the *Uintacrinus socialis* and *Marsupites testudinarius* zones here.

Later researchers have concentrated on particular parts of the stratigraphy. Mortimore (1979, 1986a,b) used the section above Whitaker's 'Flintless Belt' as the standard for his Culver Chalk Formation (originally the 'Culver Chalk Member'). This formation is now divided into the Tarrant and Spetisbury Chalk members (Bristow *et al.,* 1997; Rawson *et al.,* 2001). Mortimore also used this section as a standard for the boundary between his Culver and Portsdown Chalk members. The Flintless Belt, named the Whitecliff Member' by Gale *et al.* (1988), was illustrated in detail by Mortimore and Pomerol (1997, fig. 9) as part of their study of tectonic influences on Chalk sedimentation. A detailed log of the section from the Flintless Belt up to the top of the Chalk was provided by Gale (in Jenkyns *et al.*, 1994, fig. 15).

Key features in the lower part of this huge section (Figure 3.12) and (Figure 3.64) include the Lewes Tubular Flints and Lewes Marl at the base, a condensed upper Lewes Nodular Chalk Formation with well-developed Cliffe and Hope Gap hardgrounds, and spectacular potstone flints at the level of the Seven Sisters Flint Band.

In the centre of the section there is a bluff of harder, almost flintless chalk in the Lower Campanian Newhaven Chalk Formation, the so-called 'Flintless Belt' (Figure 3.12) and (Figure 3.65), (Figure 3.69) and (Figure 3.70), pp. 192–3), which includes several major hardgrounds and palaeoseismic horizons (Figure 3.69) and (Figure 3.71), pp. 192, 194). Towards the top of the Lower Campanian Culver Chalk Formation there are conspicuous bands of giant paramoudra flints and a range of sedimentary structures, including splitting and anastomosing flint bands.

A second bluff at the northern end of the section is created by the Portsdown Chalk Formation with numerous marl seams, the marls forming grooves in the cliff. Within the Portsdown Chalk there are special marker beds, including the Isle of Wight Tubular Flints ((Figure 3.74), p. 197), bands of abundant inoceramid bivalves and distinctive forms of the echinoid *Echinocorys.*

## Lithostratigraphy

The base of the Lewes Nodular Chalk Formation is found on the cliffs between Whitecliff Ledge and The Nostrils (Figure 3.64). Rowe (1908) found the Spurious Chalk Rock *in situ* and in fallen blocks along this section, overlain by the first grey marl (Southerham Marl 1). Rowe also found his *Bicavea rotaformis* band above the second grey marl (Caburn Marl). The section on the southern side of The Nostrils begins with beds beneath the Lewes Marl and the Lewes Tubular Flints. Above the Lewes Marl, the upper Lewes Nodular Chalk Formation contains the conspicuous Cuilfail Zoophycos Bed and the Navigation Hardgrounds and Navigation Marls. In the succeeding exposure there are two conspicuous hardgrounds, the strongly phosphatic Cliffe Hardground and the green, glauconitic Hope Gap Hardground. In comparison with Compton Bay (see GCR site report, this volume) and most mainland sections, the upper part of the Lewes Nodular Chalk is extremely attenuated (6–7 m from the Hope Gap Hardground to the Shoreham Marl), with many laminated chalk horizons and intraclast beds. The overlying basal Seaford Chalk Formation is expanded, with the first Belle Tout Marl being some 13 m above the Shoreham Marl. The typical inoceramid bivalve shell-bands (*Platyceramus* and *Volviceramus*) are strongly developed, continuing up to the Seven Sisters Flint Band (25 m above the Shoreham Marl), which has huge round potstones associated with it. These beds are on the north side of the cave controlled by the fault that runs along the Shoreham Marl.

On the far side of this headland there is a small bay that extends up to the bluffs formed by the Flintless Belt. In the southern corner of this bay there is a second fault on a marl seam, the White Horse Marl (new name herein), which is in the 'Barren Beds' of the Seaford Chalk Formation (Figure 3.66) and (Figure 3.67). Midway along this bay are seen the flint bands associated with occurrences of the inoceramid bivalve zonal index fossil, *Cladoceramus undulatoplicatus* (Roemer), at the base of the Santonian Stage. The next obvious lithological features are two well-developed nodular chalk beds, 1.8 m apart, the upper one with a glauconitized surface containing, and overlain by, glauconite-coated intraclasts (Figure 3.68). Marl seams enter above the top hardground but first become common 11 m higher, at about the entry of the zonal index crinoid, *Uintacrinus socialis* Grinnell. The marls are strongly stylolitic throughout the interval leading up to the Flintless Belt, in what is presumed to be the lower part of the Newhaven Chalk Formation (Figure 3.68).

The Flintless Belt is not entirely flintless since it contains several bands of small finger-flints as well as sheet-flints (Figure 3.69) and (Figure 3.70). The interval is also full of marl seams and there are six conspicuous green, glauconitized hardgrounds. There is an extensive burrow network beneath hardground 3. Within this flintless unit there are several examples of slump beds and seismically disrupted beds (Figure 3.71). Telscombe Marl 1 also contains rounded gravel-sized clasts of chalk. The beds above the last conspicuous slump bed contain abundant *Zoophycos,* both as grey streaks and replaced by flint (Portobello Zoophycos Beds), as well as well-developed marl seams. The change from the Newhaven Chalk Formation to the Culver Chalk Formation lithology is conspicuous (Figure 3.69) and (Figure 3.72), and is marked by the change in the cliff-line, which weathers back faster in the Culver Chalk (Figure 3.13).

Within the Culver Chalk Formation there are four groups of marls, the Lancing, Solent, Whitecliff and Yaverland marls (Figure 3.13), (Figure 3.14) and (Figure 3.72), of which the Solent Marl and Yaverland Marl are new names, not published elsewhere. These have been traced to boreholes across Langston Harbour on the mainland (Mortimore, 1998, unpublished industrial reports). Conspicuous flint bands, many of them associated with paramoudra flints, are also a feature here. Some flints show a range of unusual characters, such as a seam splitting into two or more bands, as well as highly disturbed horizons associated with low-angle sheet-flints. The division of the Culver Chalk Formation into a lower Tarrant Member and an upper Spetisbury Member is presumed to occur at the wispy Whitecliff Marls. Above these marls, paramoudra flints are more persistent and include the spectacular Warren Farm Paramoudra Flints (Figure 3.15).

The Portsdown Chalk Formation, with many marl seams, forms the next bluff in the cliff and the foreshore reef (Figure 3.12), (Figure 3.65), (Figure 3.72) and (Figure 3.73). The marl seams weather out as grooves in the cliff. The first marls do not contain abundant inoceramid bivalve shell debris, but the Bedhampton and Farlington marls are packed with inoceramid bivalves, which are commonly well preserved. A highly disturbed (slumped?) group of flints is present between the Farlington and Shide marls. A key marker bed at the point where the cliff-line changes direction from north–south to east–west is a band of tubular flints, the Isle of Wight Tubular Flints (Figure 3.74). Ten metres below the Palaeogene erosion surface is seen the last conspicuous marker flint, the Yarbridge Flint. The marl seams above this flint are faint, wispy and stylolitic (Figure 3.73). Both of these two flint marker horizons are new names, not published elsewhere.

### Biostratigraphy

As Rowe (1908) realized, collecting well-preserved fossils is difficult in this section. Despite this, all of the key marker inoceramid bivalves and shape changes in *Echinocorys* have either been collected or observed in place. Combined with the details given in Rowe (1908), a fairly complete picture of the biostratigraphy can be constructed.

The terminal Turonian–basal Coniacian inoceramid bivalve *Cremnoceramus waitersdorfensis* (Andert), associated with *Micraster normanniae* Bucaille are abundant in the beds below and in the Cliffe Hardground. The highly reduced section between the Hope Gap Hardground and the Shoreham Marl has not provided definite evidence of *C. crassus crassus* (Petrascheck), which occurs elsewhere in this interval. The beds immediately above the Shoreham Marl have also not yielded any diagnostic fossils. The presumed correlatives of the Belle Tout Marls and Seven Sisters Flint Band contain layers with abundant *Platyceramus* and *Volviceramus.* The overlying 'Barren Beds', up to the basal Santonian *Cladoceramus undulatoplicatus* beds, are, as their name implies, devoid of obvious macrofossils.

The higher Santonian fauna is more abundant, comprising many inoceramid shell debris beds and bands of the conical echinoid *Conulus albogalerus* Leske, as well as a rich mesofauna of crinoid (*Bourgueticrinus*) and asteroid ossicles. The lowest *Uintacrinus socialis* specimen so far located is associated with the beds with many stylolitic marl seams, but the exact base of its zone remains to be determined. Similarly, the base of the *Marsupites* Zone is only provisionally located, but the upper limit of the zonal index fossil at the top of the first hardground within the base of the Flintless Belt is supported by Rowe's (1908, p. 244) observations.

Within the Flintless Belt, fossils are fairly common, and the typical forms of *Echinocorys* in the Lower Campanian *Offaster pilula* and *Gonioteuthis quadrata* zones (see Newhaven to Brighton GCR site report, this volume) have been identified (Figure 3.69). The Culver Chalk is particularly barren of macrofossils, but several key *Echinocorys* horizons have been identified (Figure 3.72). In particular, large forms of *Echinocorys* (Gaster, 1924) occur in the equivalent of the Bastion Steps Beds at the top of the Newhaven Chalk Formation (i.e. *Hagenowia blackmorei* Subzone). Large, round-based post-Downend Hardground forms of *Echinocorys* (see Downend Chalk Pit GCR site report, this volume) are present in the uppermost beds (Spetisbury Member, (Figure 3.72)).

The base of the Upper Campanian *B. mucronata* Zone (*sensu stricto*) is taken at the entry of marl seams with abundant inoceramid bivalves, including *Cataceramus dariensis* (Dobrov and Pavlova). These are conspicuous in this section. In the overlying succession, an interval with *Echinocorys subconicula* Brydone is followed by an interval with *E. conica* (Agassiz) (Figure 3.73).

## Interpretation

There are very few sections as complete and accessible as Whitecliff. It is, however, anomalous in several respects (Mortimore, 1986a). The beds in the upper Lewes Nodular Chalk Formation, including the interval from the Hope Gap Hardground to the Shoreham Marl (Lower Coniacian) are attenuated, and overlain by an expanded basal part of the Seaford Chalk Formation. Hardgrounds at the top of the Seaford Chalk Formation (Lower Santonian Substage) are followed by beds with numerous stylolitic marl seams. The so-called 'Flintless Belt' is a condensed section from the top of the Upper Santonian *Marsupites* Zone to the top of the Lower Campanian 0. *pilula* Zone; the individual hardgrounds within this interval correspond to horizons with similar surfaces elsewhere (e.g. Windmill Hill, Hampshire, and Stoughton, Sussex, Mortimore, 1986b). These hardgrounds are not a general feature, but are always located along or close to known tectonic lines (see below). Higher in the Campanian succession, many of the flints in the Culver Chalk Formation, and some in the Portsdown Chalk Formation, show evidence of synsedimentary movements, but only at particular horizons.

Other research on the geochemistry and the Cretaceous palaeomagnetic reversal timescale for the 'Whitecliff section (Barchi, 1995) has identified the reversal from magnetochron 34N to 34R beneath the Old Nore Marl within the Flintless Belt. Geochemical spikes, linked to lithological and fossil event beds, provide evidence for palaeoceanographic and climatic changes in the Late Cretaceous Epoch in this section.

Whitecliff provides the standard stable isotope curves ($\delta^{13}C$, $\delta^{18}O$) for the Culver Chalk, Portsdown Chalk and basal Studland Chalk formations (Jenkyns *et al.,* 1994, fig. 7). As in the case of the curves for the underlying succession (higher Seaford Chalk, Newhaven Chalk and basal Culver Chalk formations) at Cuckmere to Seaford, the curves show a remarkable degree of covariance, suggesting that the isotope values have been affected by diagenetic processes. There is a conspicuous pair of closely-spaced 'spikes' of negative values corresponding to the marl seams at the base of the Portsdown Chalk and the paired marl seams rich in inoceramid bivalve shell debris, 5 m above, respectively.

Small pits along the Chalk Downs forming the spine of the Isle of Wight, because of their weathered state, often yield better-preserved fossils that support the identification of beds at Whitecliff. Arreton Down Pit [SZ 536 873] is one of these and has yielded beautiful, three-dimensional *Cladoceramus undulatoplicatus* at the base of the Santonian succession from Bedwell's Columnar Flint Band. This pit also exposes the basal beds of the Newhaven Chalk Formation with excellent marl seams.

Other important sections on the Isle of Wight include the difficult to access Scratchell's Bay [SZ 295 847], which, in combination with the Needles [SZ 290 849] and Alum Bay [SZ 301 851], provides a contrasting section in the Lower and Upper Campanian strata. The Newhaven Chalk Formation at the southern end of Scratchell's Bay contains numerous well-developed marl seams that correlate in detail with the standard successions at Newhaven and Seaford. In many cases the marl seams such as the Old Nore Marl are thicker than at Newhaven, comparable to those west of Brighton in the Shoreham Harbour Boreholes. Scratchell's Bay exposes, therefore, a very different, expanded Newhaven Chalk Formation in contrast to the highly condensed 'Flintless Belt' at Whitecliff. The Flintless Belt with associated hardgrounds has been traced only as far west as the Brading Pit [SZ 602 868] on Brading Down. This limits the lithology to the area of the Sandown Pericline. It was this evidence, in combination with other data indicating thinning and loss of marker beds over tectonic lines, and the evidence from seismic sections, that was used to suggest intra-Upper Cretaceous tectonic growth of structures, such as the Sandown Pericline, controlled by deeper level faults (Mortimore, 1986a,b; Mortimore and Pomerol, 1997).

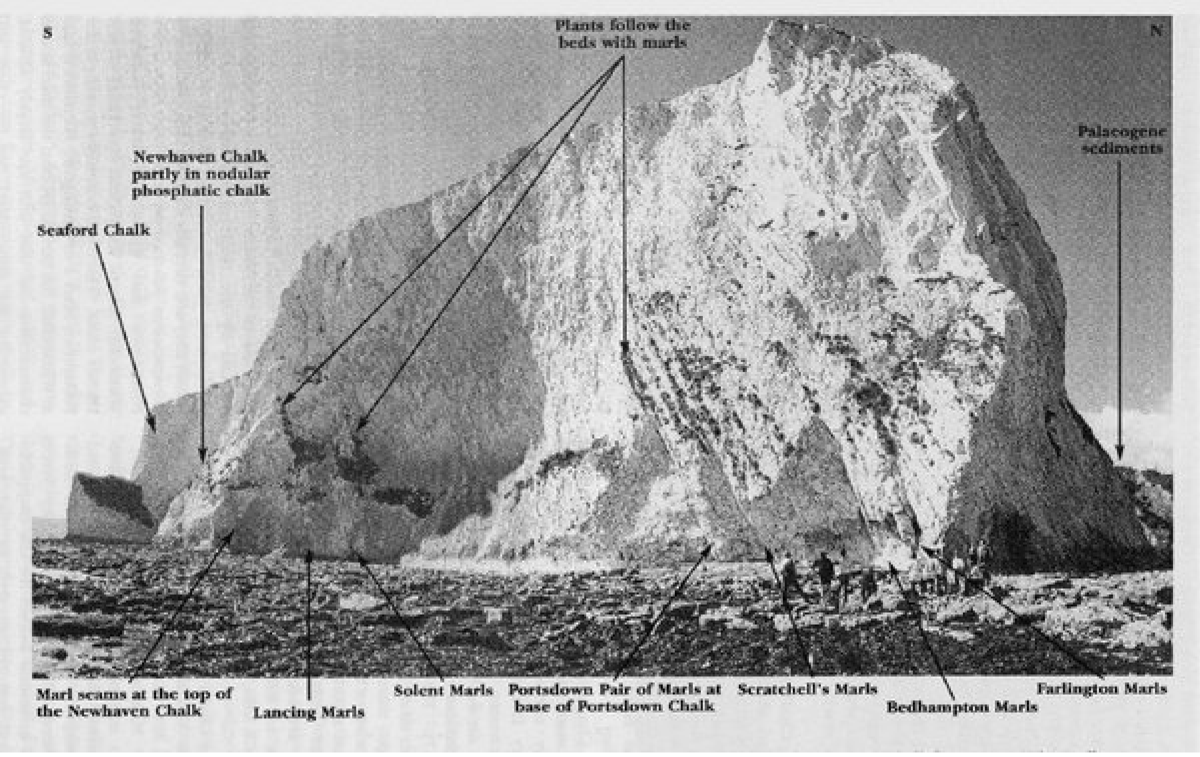
The higher beds at Scratchell's Bay in the Culver Chalk Formation contain a phosphatic chalk horizon (Bailey *et al.,* 1983, fig. 3) which was tentatively correlated with the Downend Main Hardground phosphates (see Downend Chalk Pit GCR site report, this volume). In addition, the Scratchell's Bay section was used as a standard for the Campanian microfossil biostratigraphy (Swiecicki, in Bailey *et al.,* 1983). Extrapolation of this scheme to the mainland required correlation of key marker beds such as the Whitecliff and Portsdown marls from Whitecliff to Scratchell's Bay and to the Shide Pit [SZ 505 880], which is the type locality for the Shide Marl.

Alum Bay exposes beds higher than those preserved at Whitecliff. Tectonically, Alum Bay is down the plunge east to west which continues westward to Handfast Point–Studland Bay, Dorset, and the Chalk 'youngs' in that direction. The higher beds at Alum Bay are above the Portsdown Chalk Formation in the marl-free Alum Bay Beds of Mortimore (1979, 1983; Studland Chalk Member, Gale *et al.,* 1988). These beds contain several conspicuous, marker flint bands.

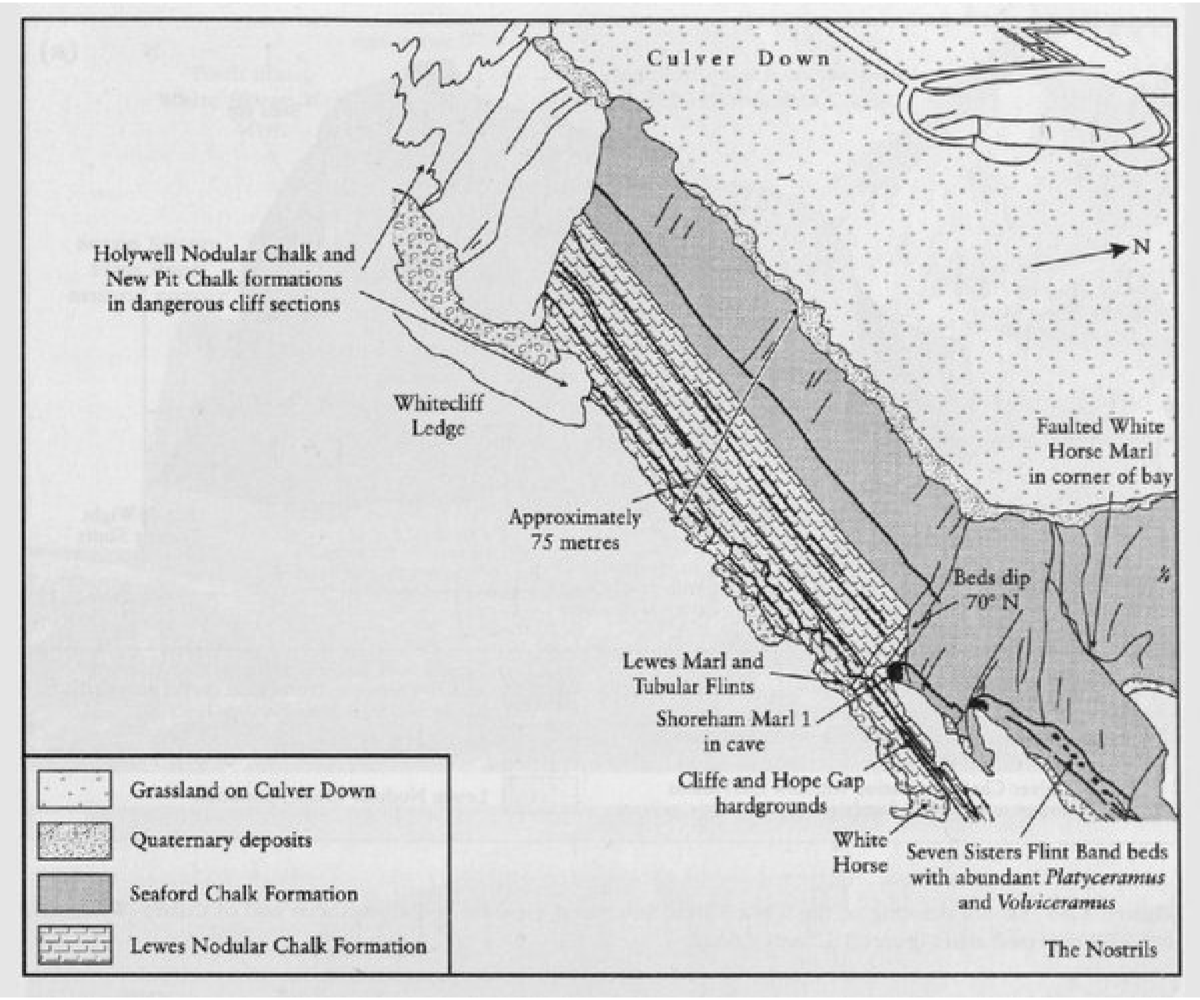
## Conclusions

Whitecliff is unique in the extent and accessibility of the stratigraphy (including stable isotope stratigraphy and magnetostratigraphy) exposed in one continuous Chalk section and it additionally provides vital evidence for sedimentary processes and tectonic control of sedimentation in the Coniacian to Campanian Chalk of the Southern Province.

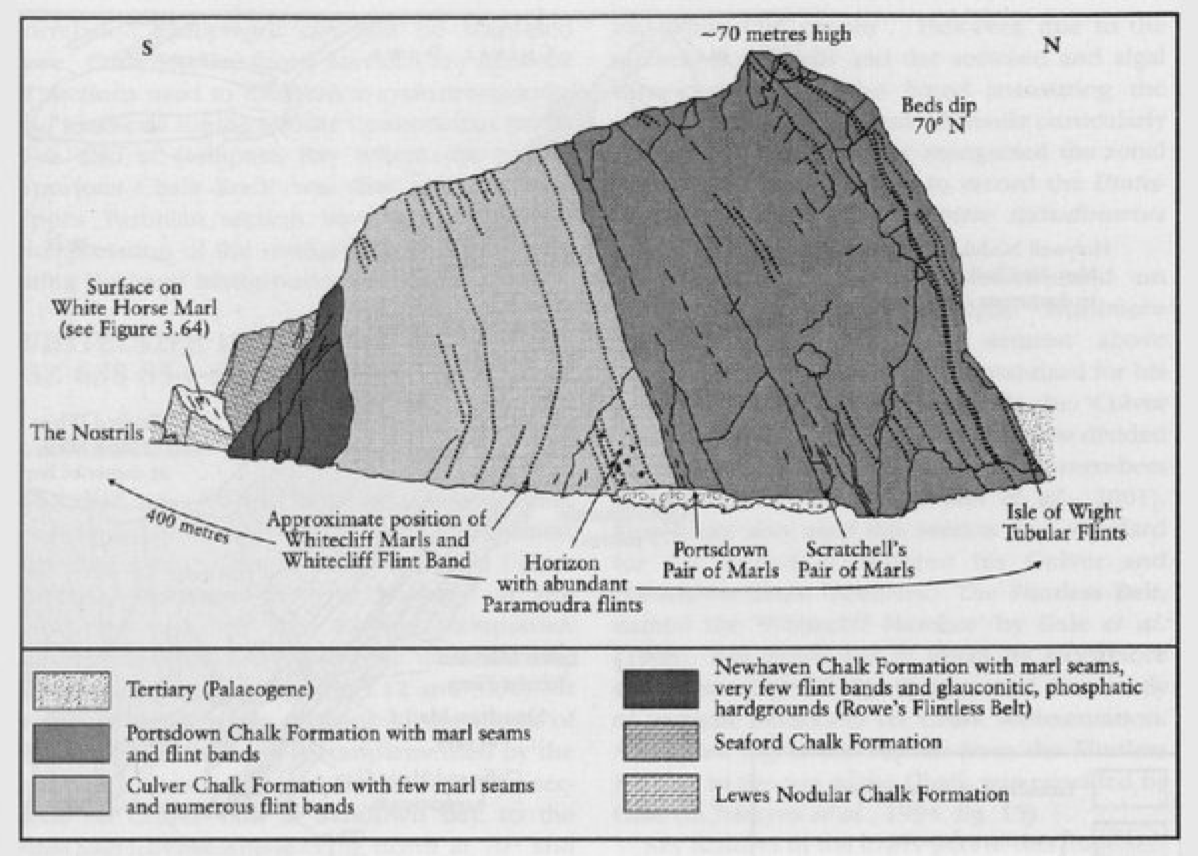
**References**



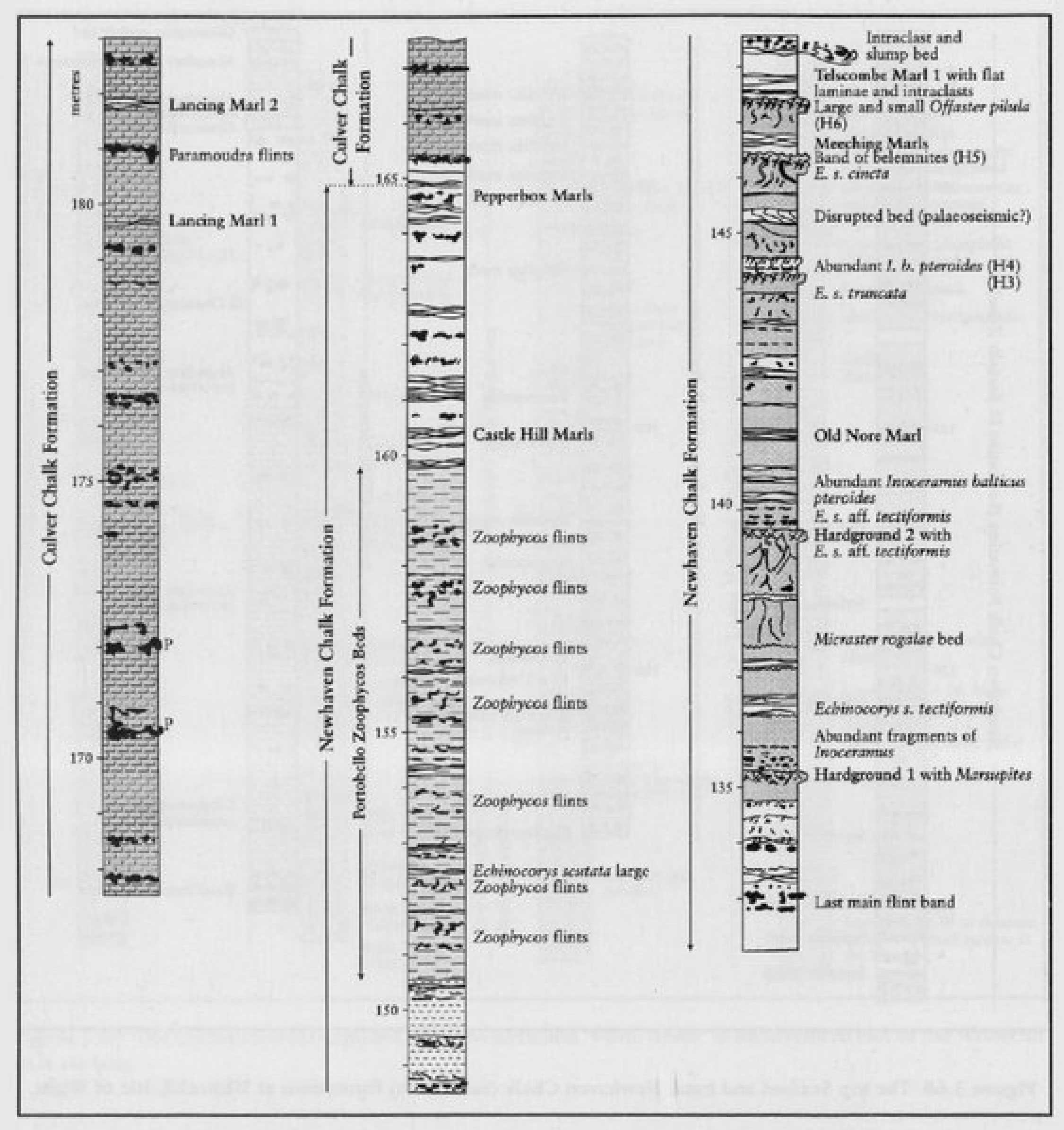

*(Figure 3.12) Whitecliff, Isle of Wight, showing the Seaford Chalk, Newhaven Chalk, Culver Chalk and Portsdown Chalk formations. The Bedhampton Marls and Farlington Marls both contain abundant inoceramid bivalve shell debris. This is the type section for the Culver Chalk Formation. Note the manly units stand out as bluffs even in the Culver Chalk Formation, which can be recognized as the unit between the top Newhaven marls and basal Portsdown marls. Compare with (Figure 3.65), p.188. (Photomosaic: R.N. Mortimore.)*



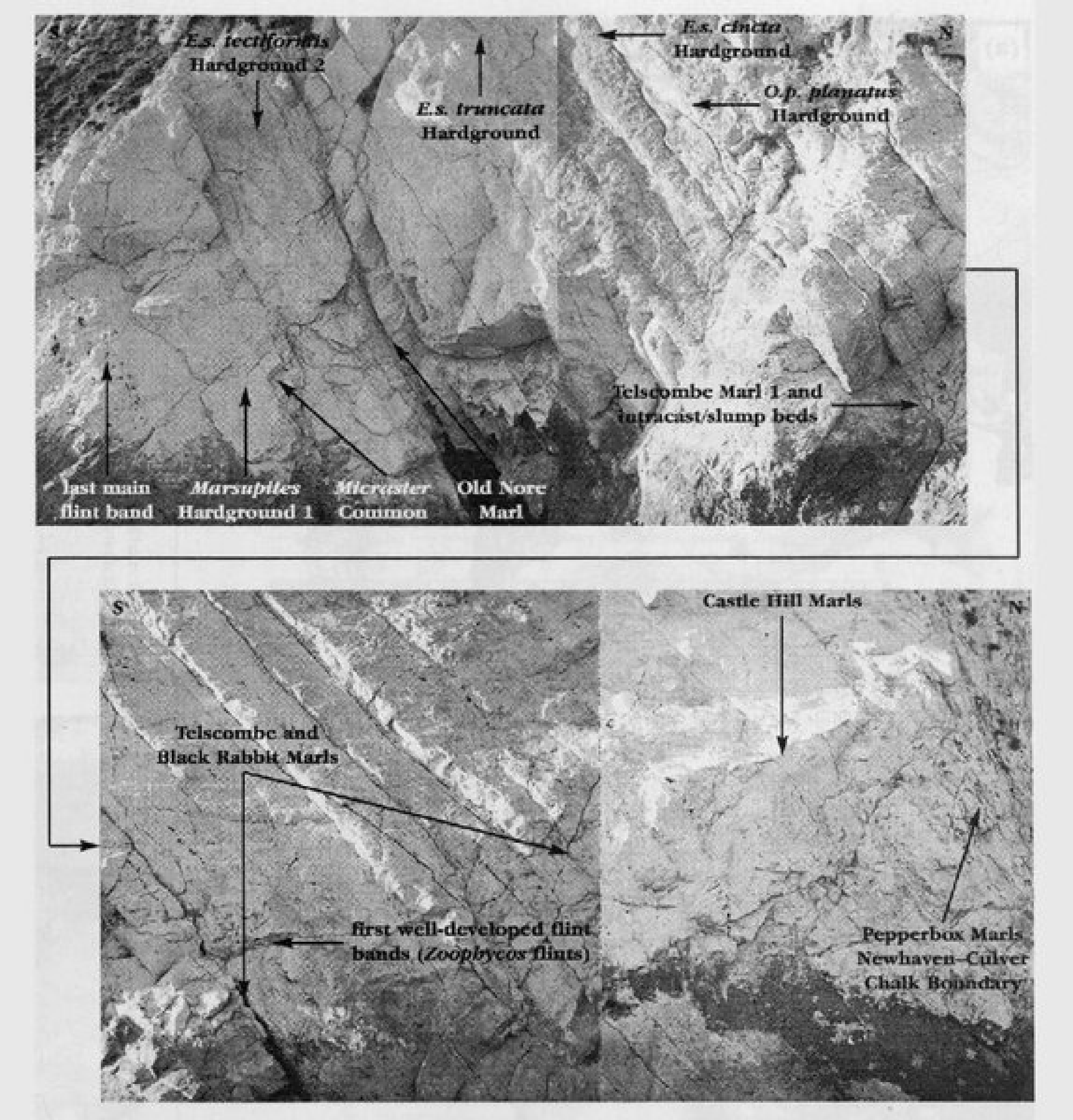

*(Figure 3.64) The southern end of the Whitecliff GCR site at Culver, Isle of Wight.*



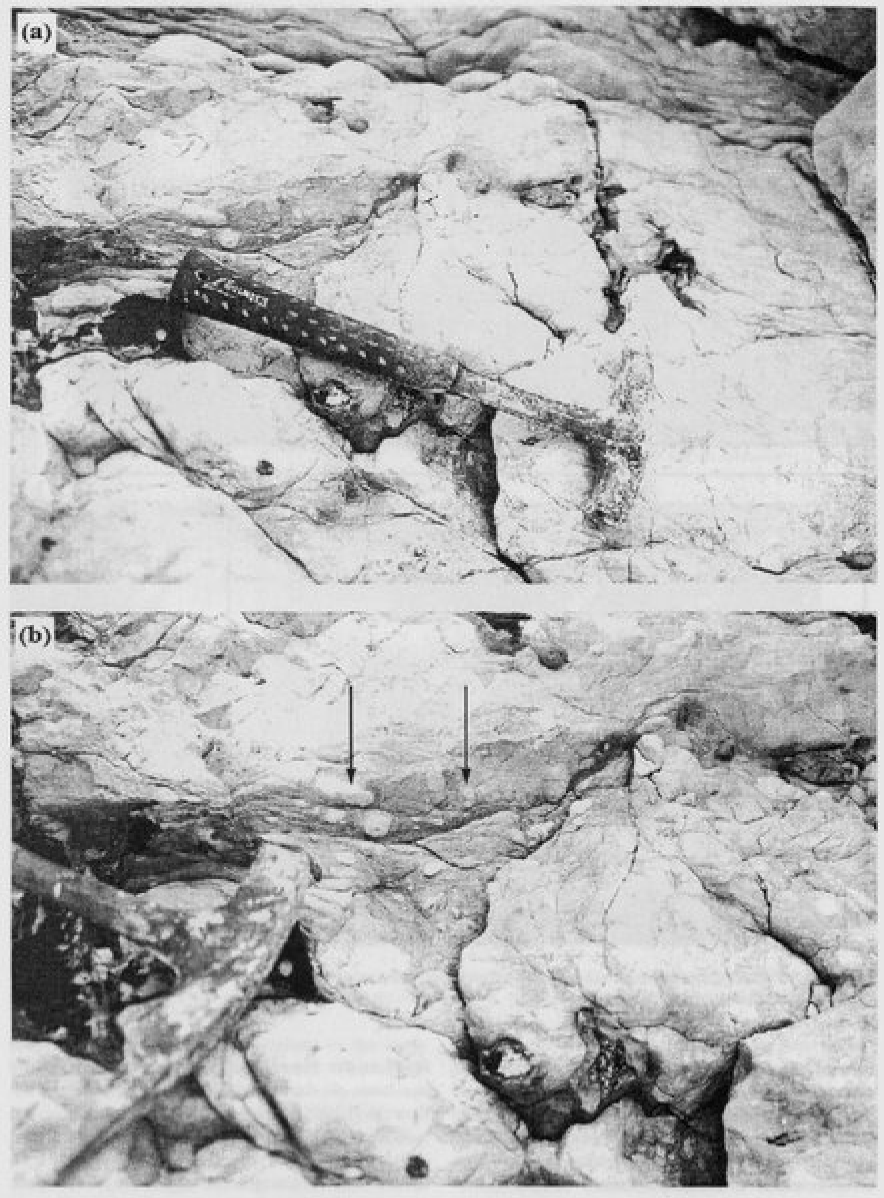

*(Figure 3.65) Sketch drawing of the White Chalk Subgroup exposed at the northern end of Culver–Whitecliff, Isle of Wight (see also Figures 3.12 and 3.66a).*



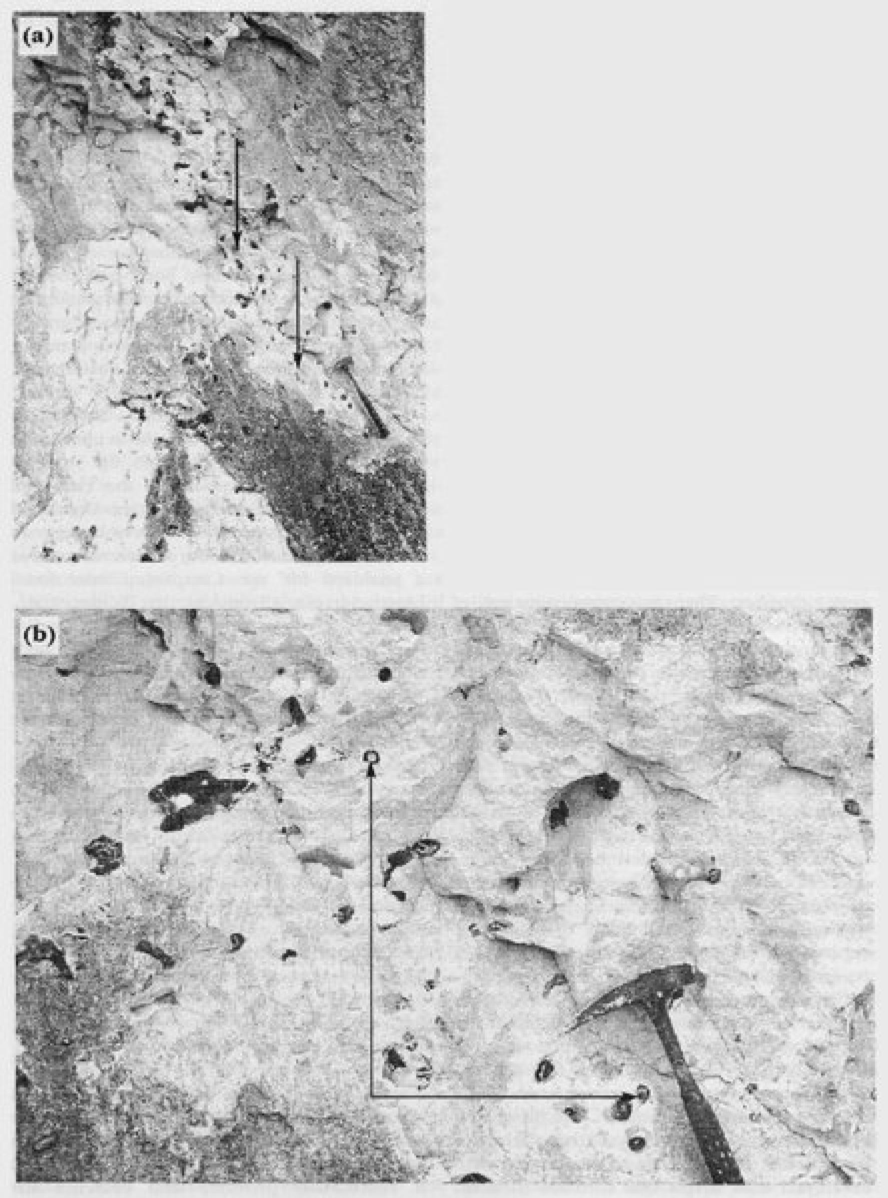

(Figure 3.69) The succession including the so-called 'Flintless Belt' of Rowe (1908) in the middle of the Whitecliff GCR section, Isle of Wight. (P = paramoudra flints.) (From Mortimore and Pomerol, 1997.)



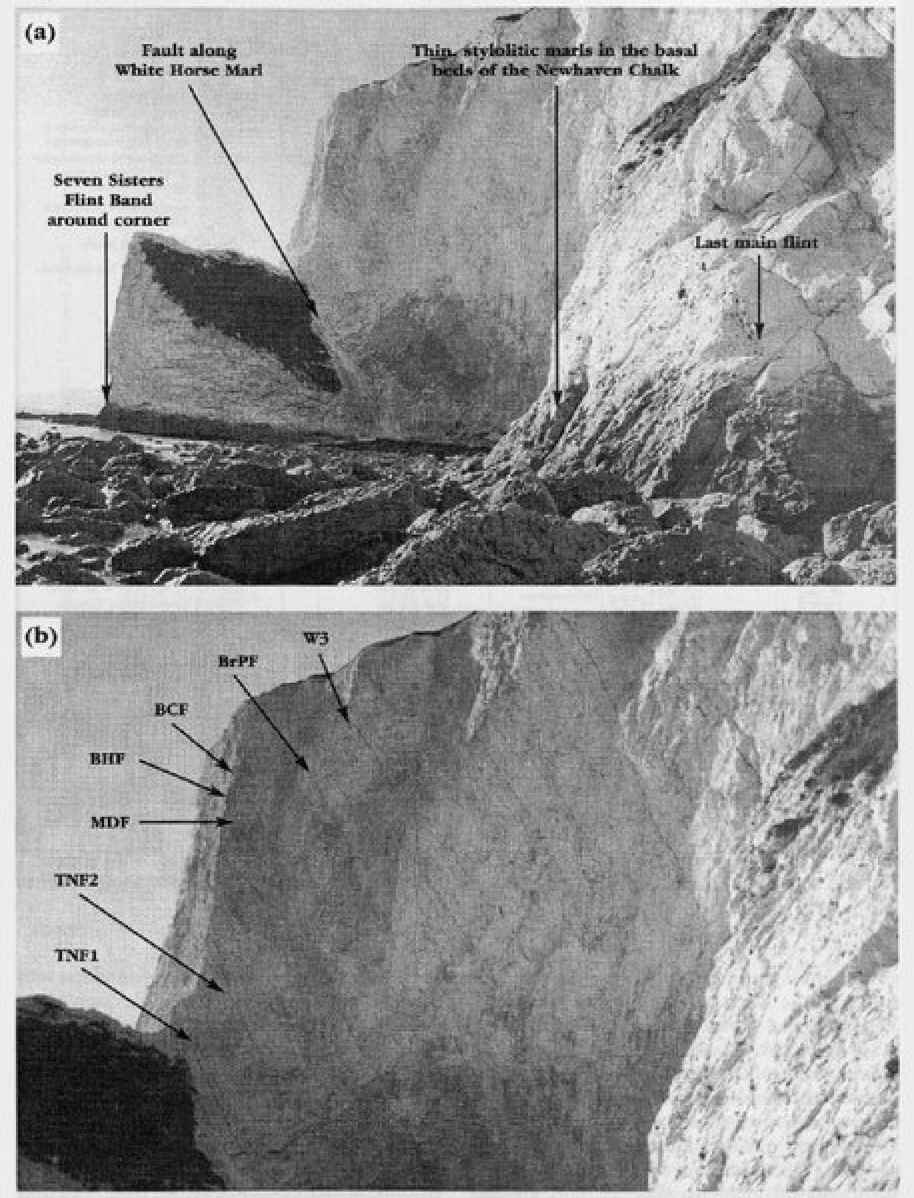

*(Figure 3.70) The 'Flintless-Chalk' unit with hardgrounds within the Newhaven Chalk Formation at Whitecliff. (Photomosaic: R.N. Mortimore.)*



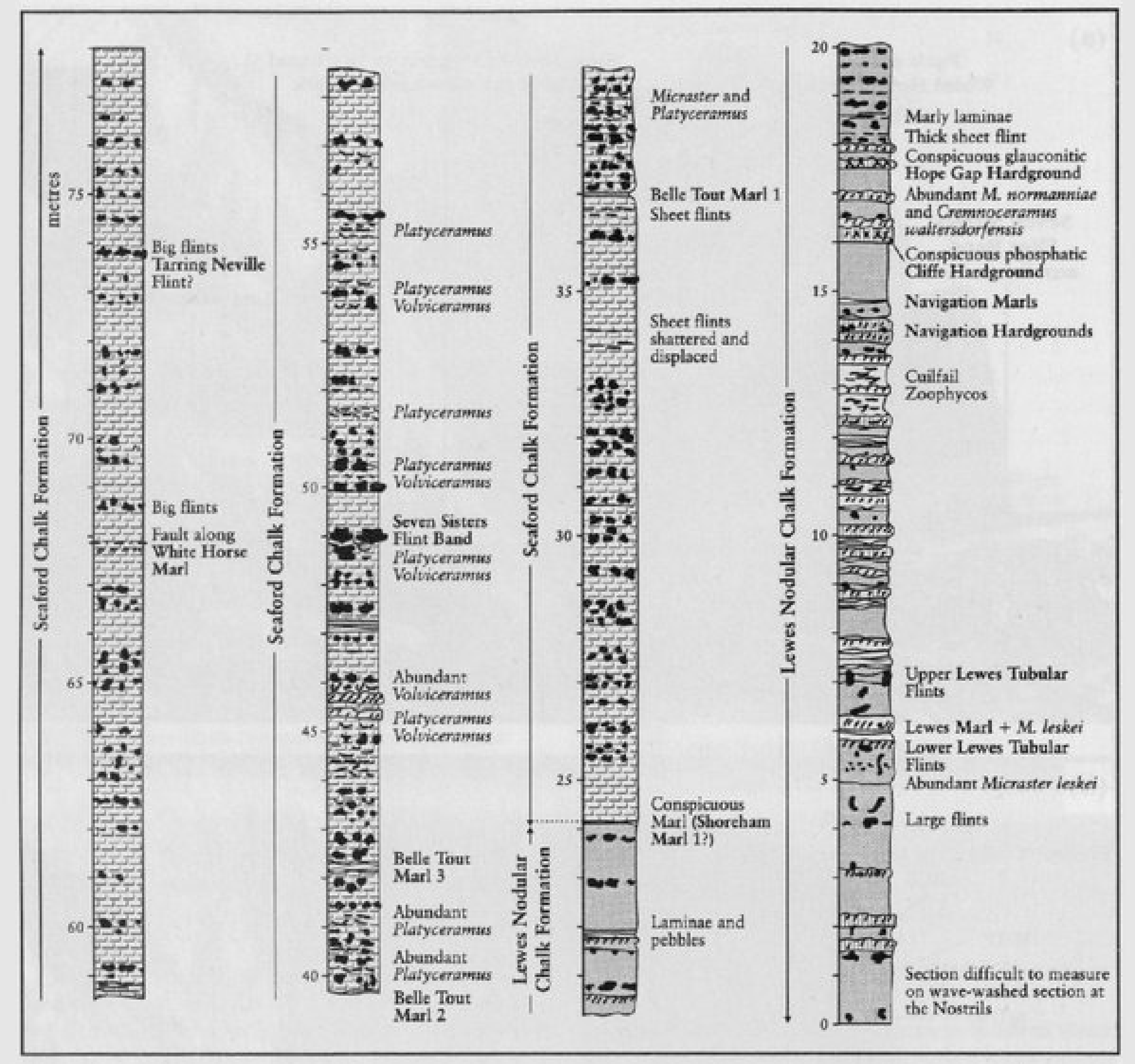
(Figure 3.71) (a, b) Intraclasts, mobilized flints and block sliding incorporating the Telscombe Marl 1, the Culver section. Intraclasts in the Telscombe Marl in (b) are arrowed. (Photos: R.N. Mortimore).



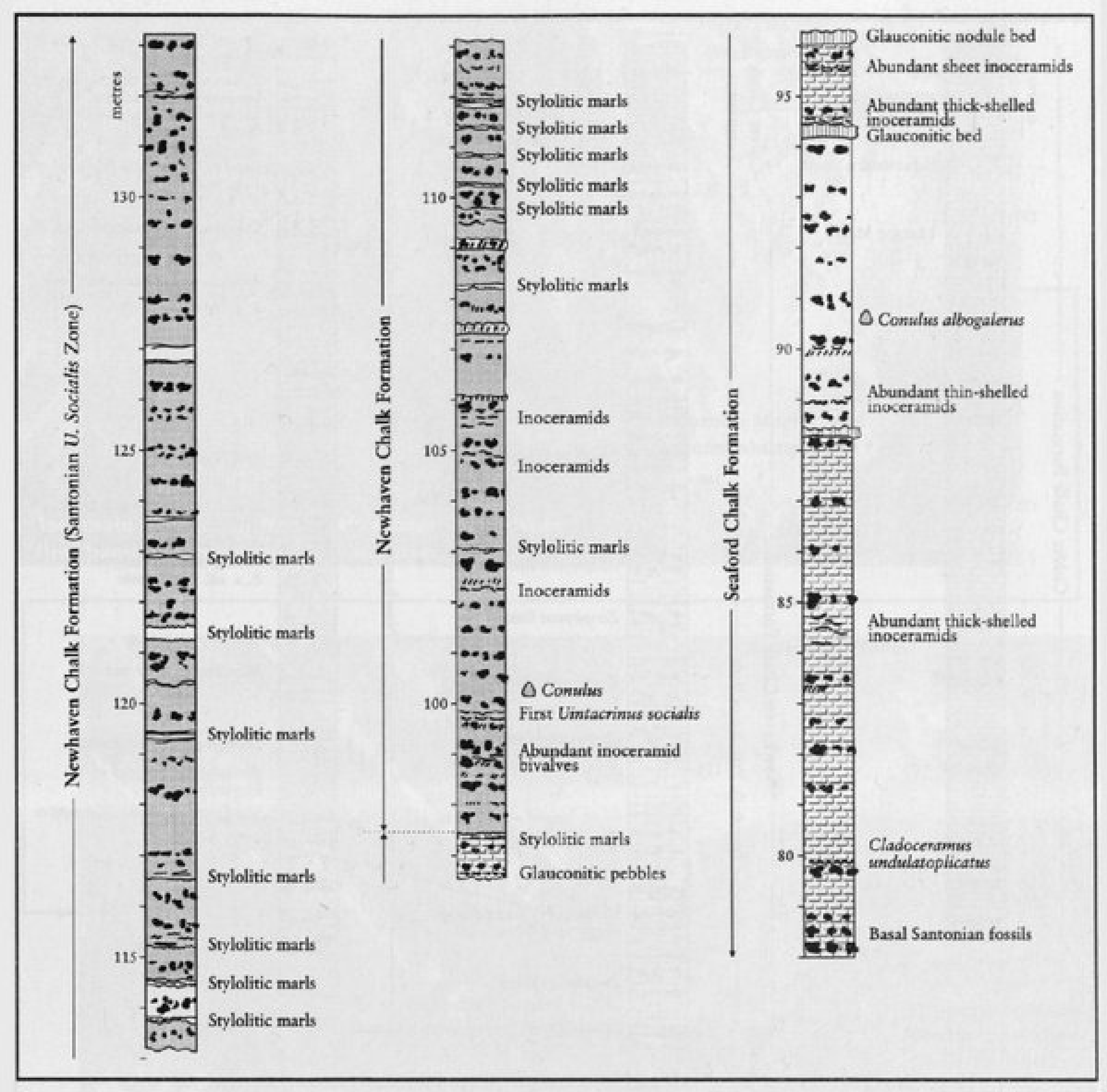

(Figure 3.74) (a, b) The Isle of Wight Tubular Flints (arrowed) in the Portsdown Chalk Formation, Whitecliff, Isle of Wight. (Photos: R.N. Mortimore.)



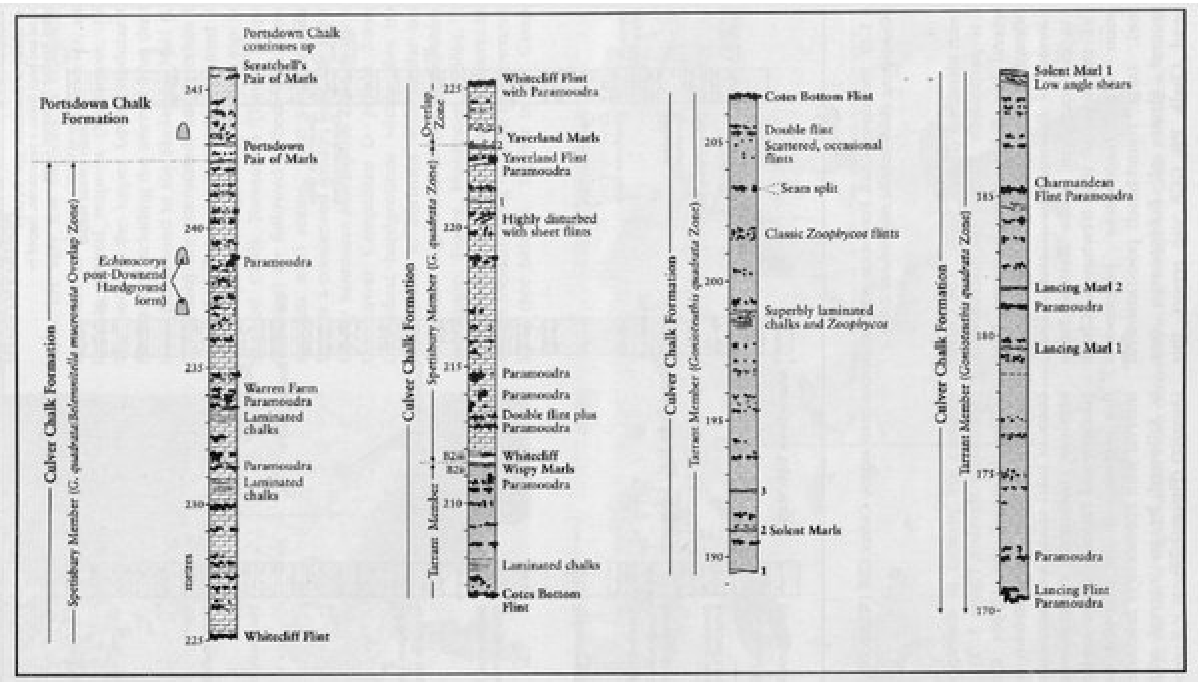

(Figure 3.66) The Seaford Chalk Formation at Whitecliff, Isle of Wight. (a) Seaford Chalk Formation and Basal Newhaven Chalk Formation. (b) Close-up of the Seaford Chalk Formation seen in centre of (a). (BCF=Bedwell's Columnar Flint; BHF=Baily's Hill Flint; BrPF=Brasspoint Flint; MDF=Michel Dean Flint; TNF1, TNF2=Tarring Neville Flints 1 and 2; W3=Whitakers's 3-inch Flint Band). (Photos: R.N. Mortimore.)



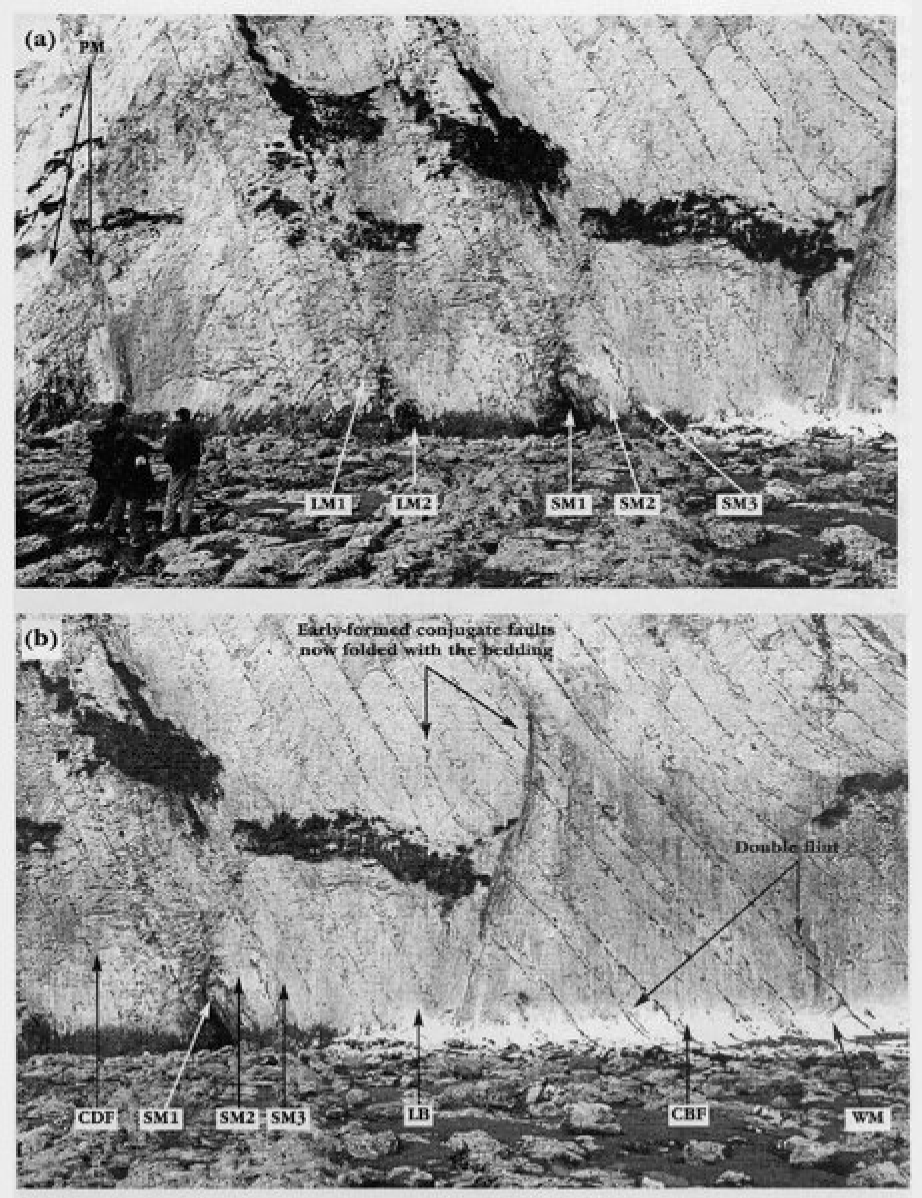

*(Figure 3.67) The lowest sections exposed at The Nostrils and 'White Horse' at the southern end of the Whitecliff GCR section.*



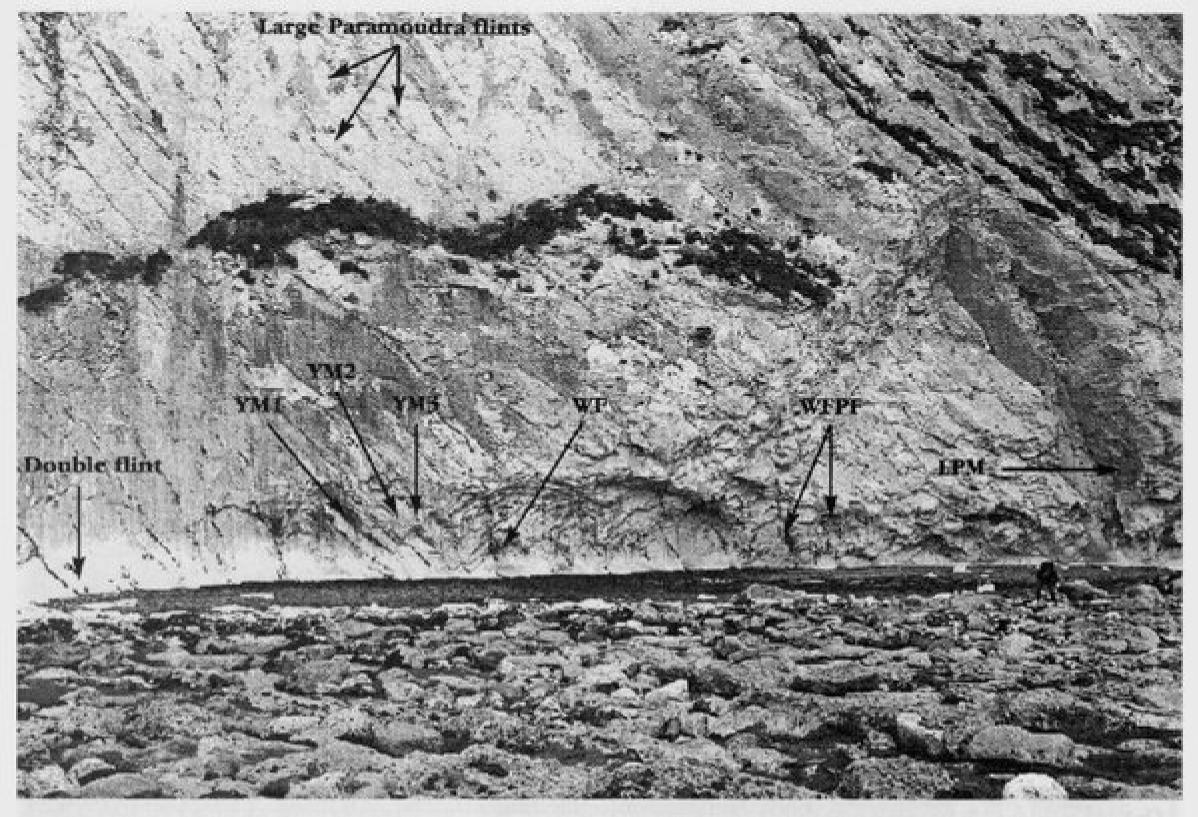

(Figure 3.68) The top Seaford and basal Newhaven Chalk (Santonian) formations at Whitecliff, Isle of Wight.



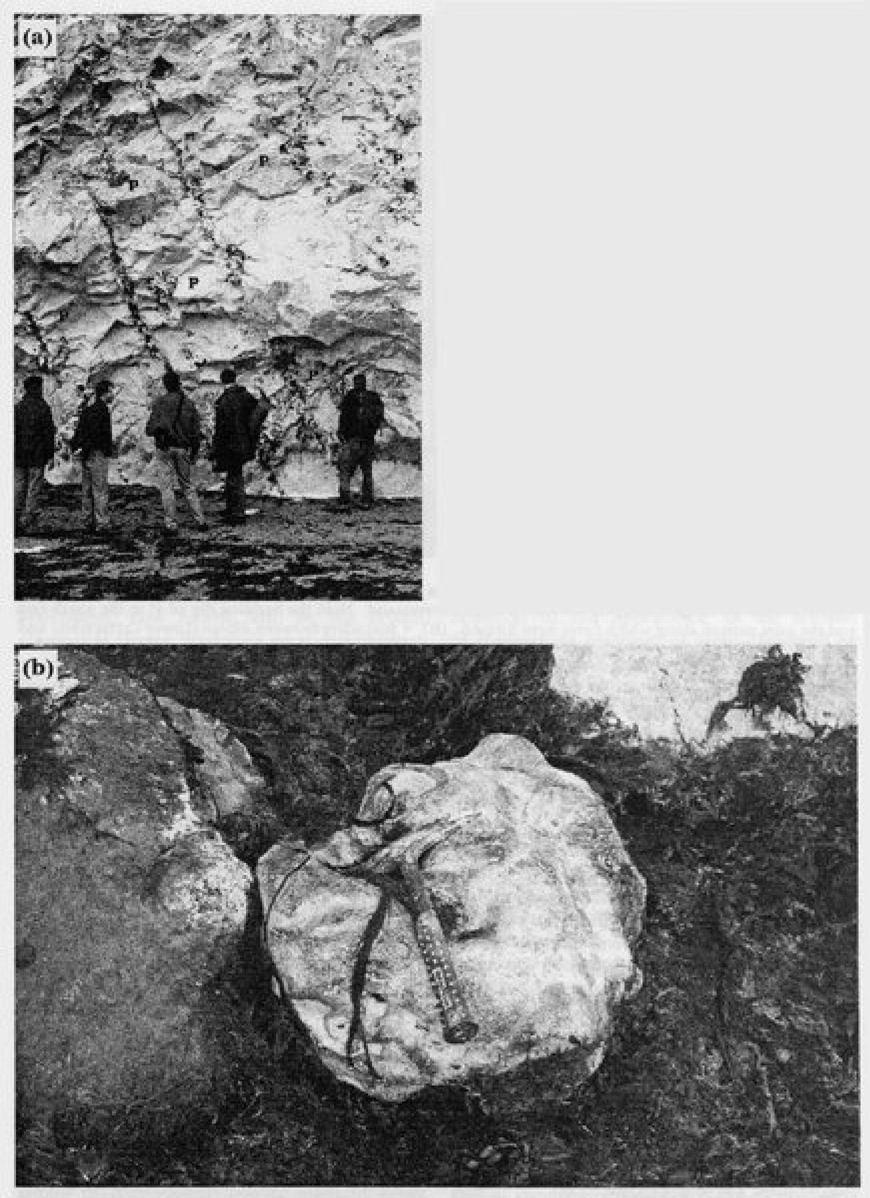

(Figure 3.72) The Culver Chalk Formation, Culver Cliff (Whitecliff GCR site), Isle of Wight. Lower Campanian Gonioteuthis quadrata Zone. (B2ii and B2iii refer to the benthic foraminiferal zonal/subzonal scheme of Swiecicki (1980).)



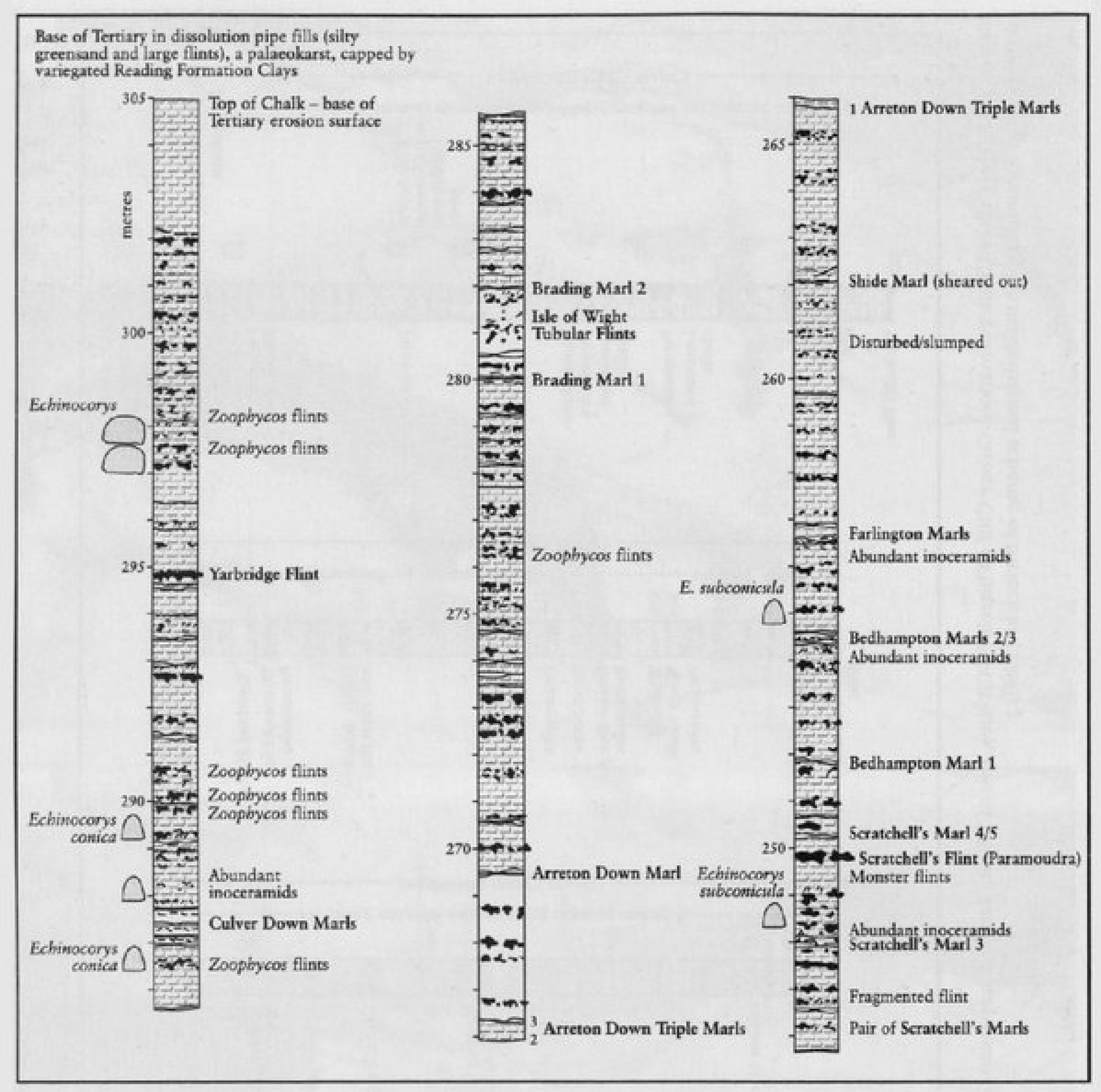

(Figure 3.13) The Culver Chalk Formation at Whitecliff, Isle of Wight. (a) The basal part of the formation. (b) The central part of the formation, the boundary between the Tarrant Member below and the Spetisbury Member above is taken at the Whitecliff Marls. (CBF = Cote's Bottom Flint; CDF= Charmandean Flint; LB = Laminated beds; LM1, LM2 = Lancing Marls 1 and 2; PM = Pepperbox Marls at top of Newhaven Chalk Formation; SM1, SM2, SM3 = Solent Marls 1, 2 and 3; WM = Whitecliff Marls.) (Photos: R.N. Mortimore.)




(Figure 3.14) The upper part of the Culver Chalk Formation, Whitecliffe, Isle of Wight (Spetisbury Member) containing numerous Paramoudra flints. (LPM = Lower Portsdown Marls; WF = Whitecliffe Flint; WFPF = Warren Farm Paramoudra Flints; YM1, YM2, YM3 = Yaverland Marls 1, 2 and 3.) (Photo: R.N. Mortimore.)




(Figure 3.15) (a) Large Paramoudra flints (P) from the Warren Farm Paramoudra horizon, Whitecliff, Isle of Wight. (b) Large Paramoudra flint fallen to the beach, Whitecliff, Isle of Wight. (Photos: R.N. Mortimore.)




*(Figure 3.73) Portsdown Chalk Formation with numerous marl seams, Culver Cliff (Whiteclift), Isle of Wight, Upper Campanian Belemnitella mucronata Zone.*