WHITE NOTHE

OS Grid Reference: SY764813–SY788806

Introduction

White Nothe forms a major exposure (Figures 3.46–3.48) in the Cenomanian to Campanian part of the Upper Cretaceous Series (Figure 1.2, Chapter 1). It is divided into two parts. The first part encompasses the western end of the site (Figure 3.47) from just east of Holworth House to the old coastguard lookout (White Nothe Cottages) at the point of White Nothe (White Nose). This is a broad area of landslipping that is progressively more developed westwards where the clay formations of the Jurassic System and the Cretaceous Gault become exposed at the base of the cliff. The landslips have left a huge vertical wall of Turonian to Coniacian Chalk in front of which are numerous rotated blocks that are used to reconstruct the geology. The second part includes the steep cliffs below and to the east of White Nothe to the central part of Middle Bottom at the eastern extremity of the site. Tectonic disturbance is pronounced in West Bottom and Middle Bottom (Figures 3.47, 3.49 and 3.50). This huge, landslipped coastal section contains a spectacular unconformity between the Jurassic succession and the overlying Cretaceous (Gault, Greensand and Chalk). It is the most westerly coastal exposure of the higher Middle and Upper Cenomanian Zig Zag Chalk Formation of the Grey Chalk Subgroup, before it condenses into the higher Basement Beds of south-east Devon. The Zig Zag Chalk Formation has a glauconitic, sandy base which rests, not on marly chalk typical of the main basin to the east, but on highly condensed Cenomanian Basement Beds. In turn, these thin Cenomanian deposits rest on a complex succession of Albian Greensand and Chert Beds. The succession at White Nothe has been described as the best demonstration of Cenomanian onlap in southern England.

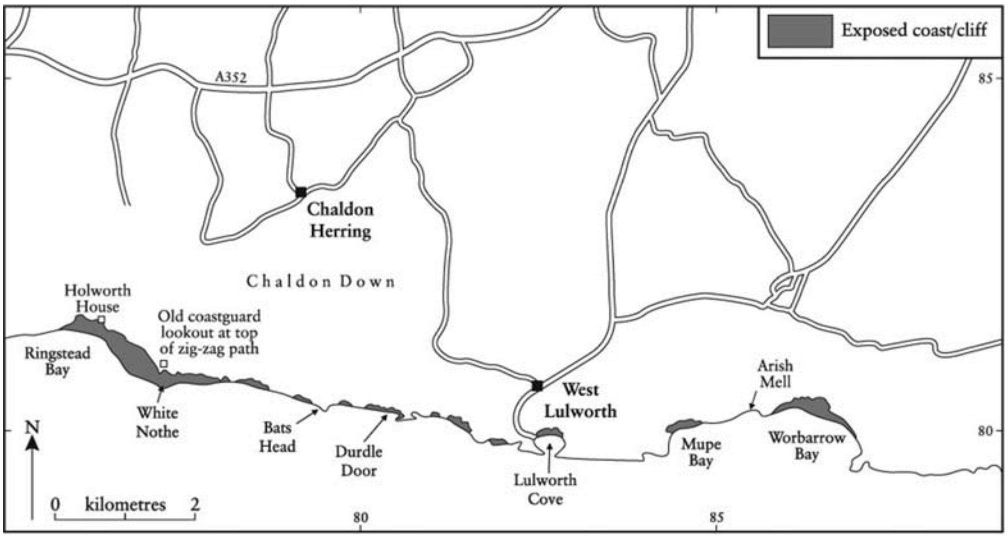

Figure 3.46: The White Nothe GCR site in relation to other key Late Cretaceous sections on the adjacent Dorset Coast.

Series	Age (Ma)	Stages	Time span
Upper Cretaceous	65.4	**Maastrichtian** (Dumont, 1849)	5.9
Upper Cretaceous	71.3	**Campanian** (Coquand, 1857)	12.2
Upper Cretaceous	83.5	**Santonian** (Coquand, 1857)	2.8
Upper Cretaceous	86.3	**Coniacian** (Coquand, 1857)	2.4
Upper Cretaceous	88.7	**Turonian** (d'Orbigny, 1840–47)	4.6
Upper Cretaceous	93.3	**Cenomanian** (d'Orbigny, 1840–47)	5.2
Lower Cretaceous	98.5	**Albian** (d'Orbigny, 1840–47)	13.5
Lower Cretaceous	112	**Aptian** (d'Orbigny, 1840–47)	9.0
Lower Cretaceous	121	**Barremian** (Coquand, 1861)	6.0
Lower Cretaceous	127	**Hauterivian** (Renevier, 1874)	3.0
Lower Cretaceous	130	**Valanginian** (Desor, 1854)	5.0
Lower Cretaceous	135	**Berriasian**	7.0
Lower Cretaceous	142		

Figure 1.2: Cretaceous (D'Halloy, 1822) series and stages (Birkelund et al., 1984). Age picks (Ma = million years) based on Obradovitch (1993) and Gradstein et al. (1999). (Dates obtained using 40Ar/39Ar laser fusion on 50–500 µg samples of sanidine from bentonites (volcanic ash/marls) interbedded with precisely dated fossiliferous marine sediments.)

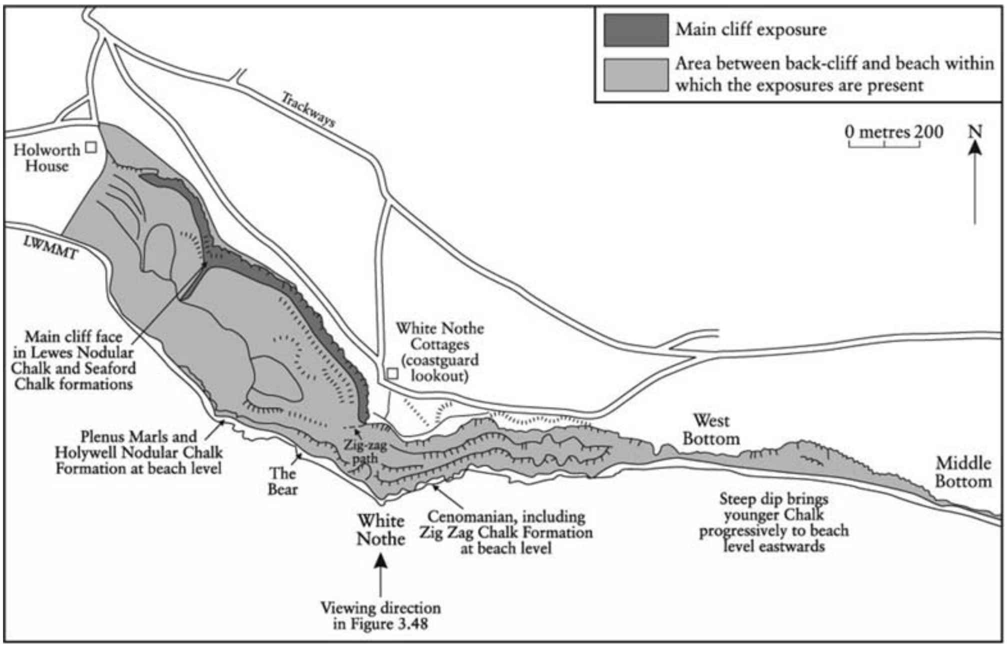

Figure 3.47: Map of the White Nothe GCR site, see also Figure 3.48.

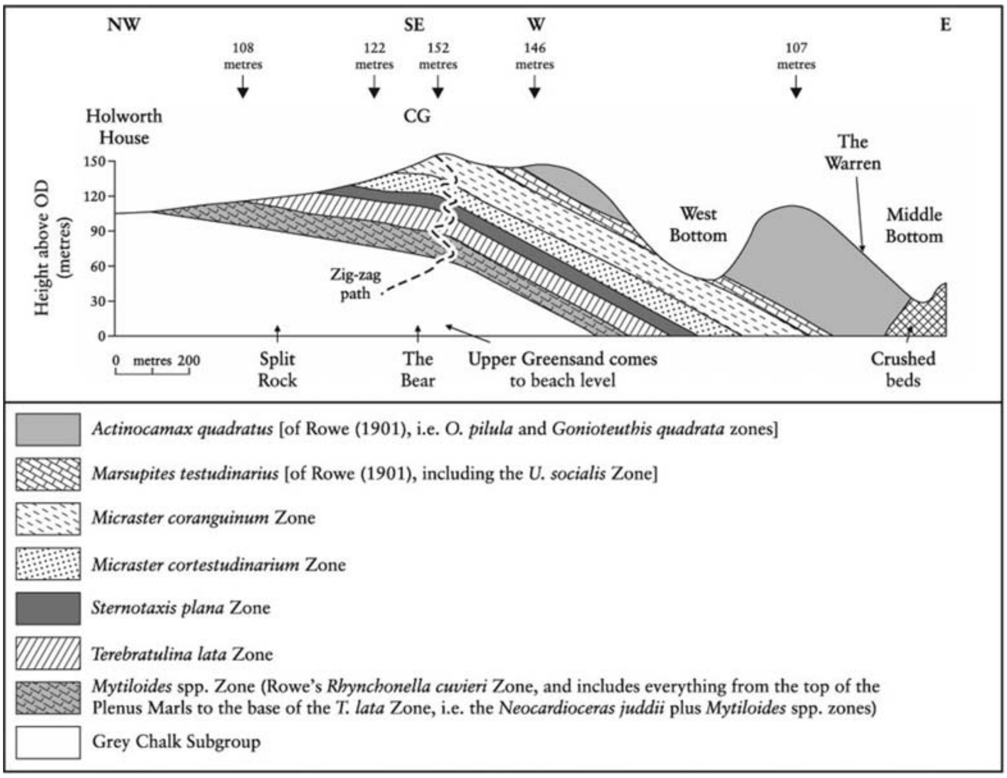

Figure 3.49: White Nothe showing the zones of the Chalk in relation to the old coastguard lookout (CG = White Nothe Cottages on Figure 3.48) and the zig-zag path. (After Rowe, 1901, fig. 1.)

Figure 3.50: Looking east from White Nothe across Middle Bottom to Bats Head. (Photo: R.N. Mortimore.)

Higher in the succession, hardgrounds and nodular chalks have formed on spectacular erosional surfaces in the Lower Coniacian upper Lewes Nodular Chalk Formation. In combination, the Cenomanian onlap and the Coniacian erosional events illustrate key aspects of Late Cretaceous stratigraphy and sedimentary processes.

Description

Access to the White Nothe sections is exceedingly difficult and involves trekking through small paths and thick undergrowth or scaling the steep cliffs. The main access is via a zig-zag path from the old coastguard lookout (White Nothe Cottages – Figures 3.47 and 3.48) through the landslipped blocks that eventually leads to beach level. The Cenomanian sections are not always well exposed, depending on the amount of slipped debris. Turonian sections are rarely exposed in their entirety and have to be pieced together from intermittent exposures and boulder falls. Steep, near vertical walls of gritty, red, iron-stained nodular chalk characterize the Upper Turonian–Lower Coniacian Lewes Nodular Chalk Formation, which can be studied in bluffs below and west of the old coastguard lookout. The highest Chalk exposed in the bluffs near the top of these cliffs adjacent to the old coastguard lookout are in the Upper Coniacian and Lower Santonian Seaford Chalk Formation (Figures 3.51 and 3.52).

Figure 3.48: White Nothe, Dorset, landslipped masses of Chalk and the zig-zag path from the old coastguard lookout (White Nothe Cottages) through the landslipped masses. (Photo: Cambridge University Collection of Aerial Photography: copyright reserved).

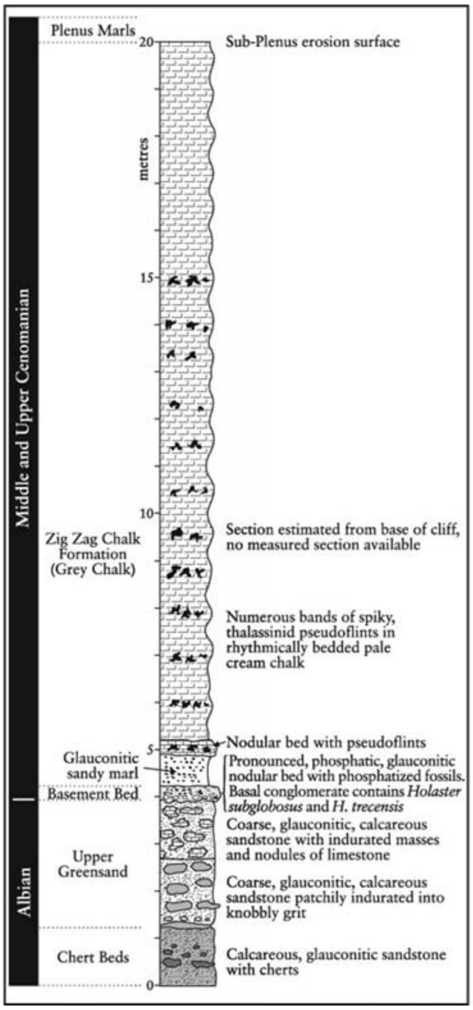

Figure 3.51: Upper Greensand/Chalk contact and the Zig Zag Chalk succession exposed at the base of White Nothe cliffs, Dorset, in the landslipped masses.

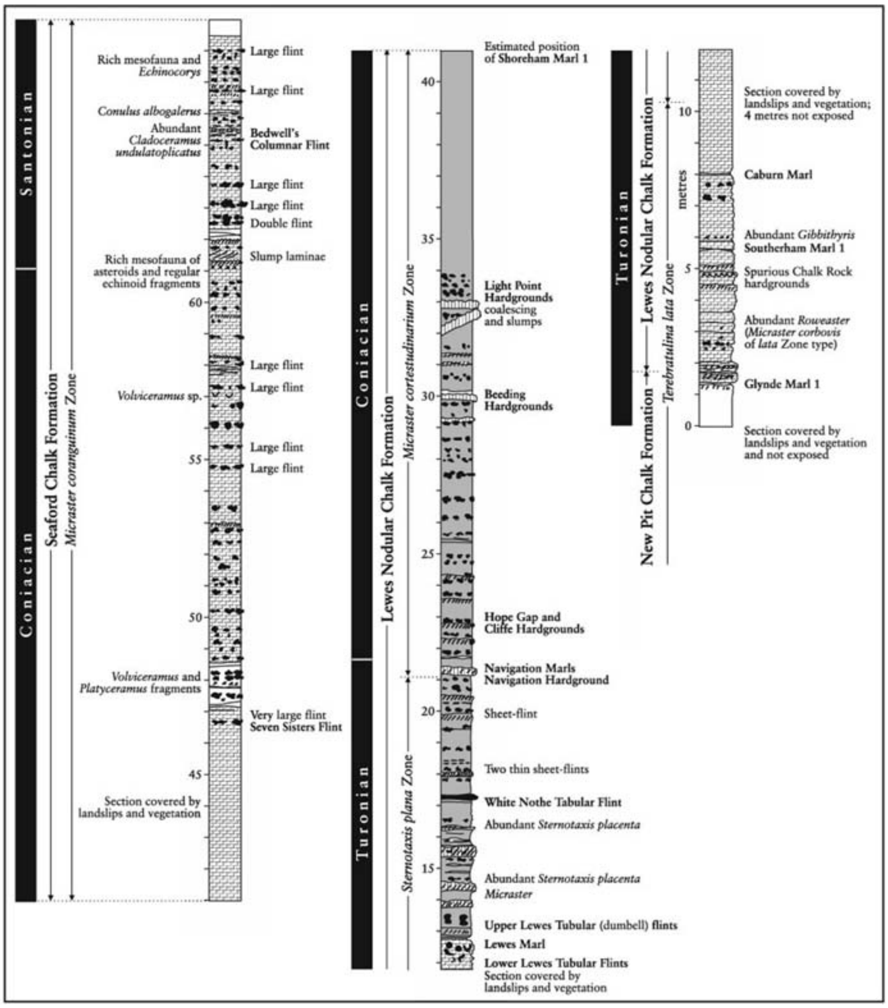

Figure 3.52: Part of the Chalk succession exposed at White Nothe, Dorset, in the slipped masses and in the cliff.

To the east, the steep northerly dip brings the higher beds of the Seaford Chalk, Newhaven Chalk, and Culver Chalk formations to beach level. The Newhaven Chalk Formation at Bats Head just east of the site boundary (Figure 3.50) is discernable by the weathering out of marl seams to form conspicuous grooves in the high cliff face.

Despite its spectacular nature and importance to Cretaceous stratigraphy there are no complete, published measured sections of White Nothe. A first attempt at zoning these cliffs was made by Barrois (1876), who also provided a measured section in the uppermost bluffs containing parts of the Lewes Nodular Chalk and Seaford Chalk formations. The most complete and historically most important account is by Rowe (1901), who divided the section into two parts; the undercliff along the shoreline, and the top of the cliff in the landslipped bluffs. The [British] Geological Survey (Jukes-Browne and Hill, 1904) largely followed Rowe's account of this section. Brydone (1914) provided some lithological and paleontological details in the Newhaven Chalk. Later researchers have looked at parts of the succession only. Drummond (1967, 1970) investigated the Albian–Cenomanian strata, but the field section is described only in his unpublished PhD Thesis (1967). Mortimore and Pomerol (1987, fig. 9) investigated the Turonian–Santonian sections but published only part of their measured section. Gale (1996, fig. 7) provided a graphic log of part of the Lewes Nodular Chalk Formation, from Southerham Marl 1 to the Cliffe Hardground. The details given in this account are a combination of these sources.

Grey Chalk Subgroup

The typical basin succession in the Grey Chalk Subgroup, seen in Sussex and Kent, where it is divided into the West Melbury Marly Chalk and Zig Zag Chalk formations, is not present at White Nothe. Instead there are two units; the first is broadly termed 'Cenomanian deposits' and represents a highly condensed West Melbury Marly Chalk and lower part of the Zig Zag Chalk formations, and the second is a lithological variant of the Zig Zag Chalk Formation.

The Cenomanian deposits at White Nothe are recorded as 24 m thick by Drummond (1967, p. 44) and about 15 m by House (1993). This difference in thickness relates not only to the difficulty of measuring a complete section but to the possible tectonic thinning considered by Drummond (1967). Within this succession, Drummond recorded about 1.5 m of Chert Beds (pars) followed upwards by 1.5 m of nodular sandstone, a similar thickness of nodular limestone and then the highly condensed 1 m thick Cenomanian Basement Beds representing the entire Lower Cenomanian and part of the Middle Cenomanian successions. The remaining part of the Middle and Upper Cenomanian succession is represented by the pale coloured Zig Zag Chalk Formation (the 'Grey Chalk' of Drummond, 1970) with a basal sandy layer. Bands of pale, porcellaneous flints are present. These flint bands are concentrated in the lower part of the Zig Zag Chalk Formation and are wonderfully spiky, having replaced the fill of thalassinid crustacean burrows. Eastwards, towards and in the main basin, flints are entirely absent from the Grey Chalk Subgroup, but flint is common in the Cenomanian strata of the south-west margin of the basin in France at Antifer-Tilleul (Pays de Caux) as well as in Wessex (Mortimore and Pomerol, 1987).

Rowe (1901) worked the coast sections beneath and east of White Nothe by boat. He noted that the Zig Zag Chalk comprised alternating hard and soft layers which weathered out at the foot of the headland giving the place a (p. 8) ' ...strikingly sculptured appearance'.

White Chalk Subgroup

The basal units of the White Chalk Subgroup comprising the Upper Cenomanian Plenus Marls Member–Melbourn Rock–Meads Marls interval (as defined in Sussex, Mortimore, 1986a), is well exposed here but has not been logged in detail. Rowe described the Holywell Nodular Chalk Formation (his *Rhynchonella cuvieri* Zone) as very hard and nodular with pyrite nodules and occasional marl seams and about 76 ft (23 m) thick. He noted a flint band at the junction between his *R. cuvieri* Zone and the overlying 58 ft (18 m) thick *Terebratulina gracilis* (i.e. *lata*) Zone. On the basis of correlation with the Worbarrow Bay and the **Handfast Point to Ballard Point** sections (see GCR site report, this volume), this flint band probably equates with the Glyndebourne Flints at the base of the New Pit Chalk Formation. Rowe noted a 5 ft (1.5 m) thick band of yellow-green nodules not far above the base of the *T. lata* Zone, which earlier observers had correlated with the Chalk Rock. In his later study of the Isle of Wight, Rowe (1908) termed these nodules the 'Spurious Chalk Rock' on the basis that they were located in the *T. lata* Zone rather than in the overlying *Sternotaxis plana* Zone. Rowe's observations support the suggestion that most, if not all, of the New Pit Chalk Formation may be missing here: the Lewes Nodular Chalk Formation, with the Spurious Chalk Rock at the base, appears to rest almost directly on Holywell Nodular Chalk Formation (Freshney, pers. comm., 1998).

The intermittent exposures in the Holywell Nodular Chalk and New Pit Chalk formations in the landslip masses to the west, and above the beach, do not allow a complete section to be logged, but typical Holywell Nodular Chalk Formation lithologies with abundant *Mytiloides* shell-debris beds and griotte or flaser marls are present.

The Lewes Nodular Chalk Formation is spectacularly air-weathered in the vertical faces of the high chalk cliffs beneath and west of the coastguard lookout. This enhances the nodular character of the formation. In addition, all of the major marker beds including the marker tephro-event marl seams have been identified (Figures 3.9, 3.48 and 3.52; Figure 2.9 Chapter 2; Mortimore and Pomerol, 1987, fig. 9). The Lower Lewes Tubular Flints with the overlying Lewes Marl are conspicuous. As at the **Compton Bay** GCR site, the marl here contains abundant crinoid (*Isocrinus dixoni*) and other shelly fragments as well as *Micraster leskei*. A very conspicuous thick, tabular flint, the White Nothe Flint, for which this is the type locality, is present between the Lewes Marl and the Navigation Marls. This is a marker flint traceable north to the **Shillingstone Quarry** GCR site and east to the **Handfast Point to Ballard Point** GCR site. Towards the top of the Lewes Nodular Chalk, at about the level of the Light Point Hardgrounds, there are two red, iron-stained and mineralized hardground surfaces which form along obvious erosional channels (Figure 3.52).

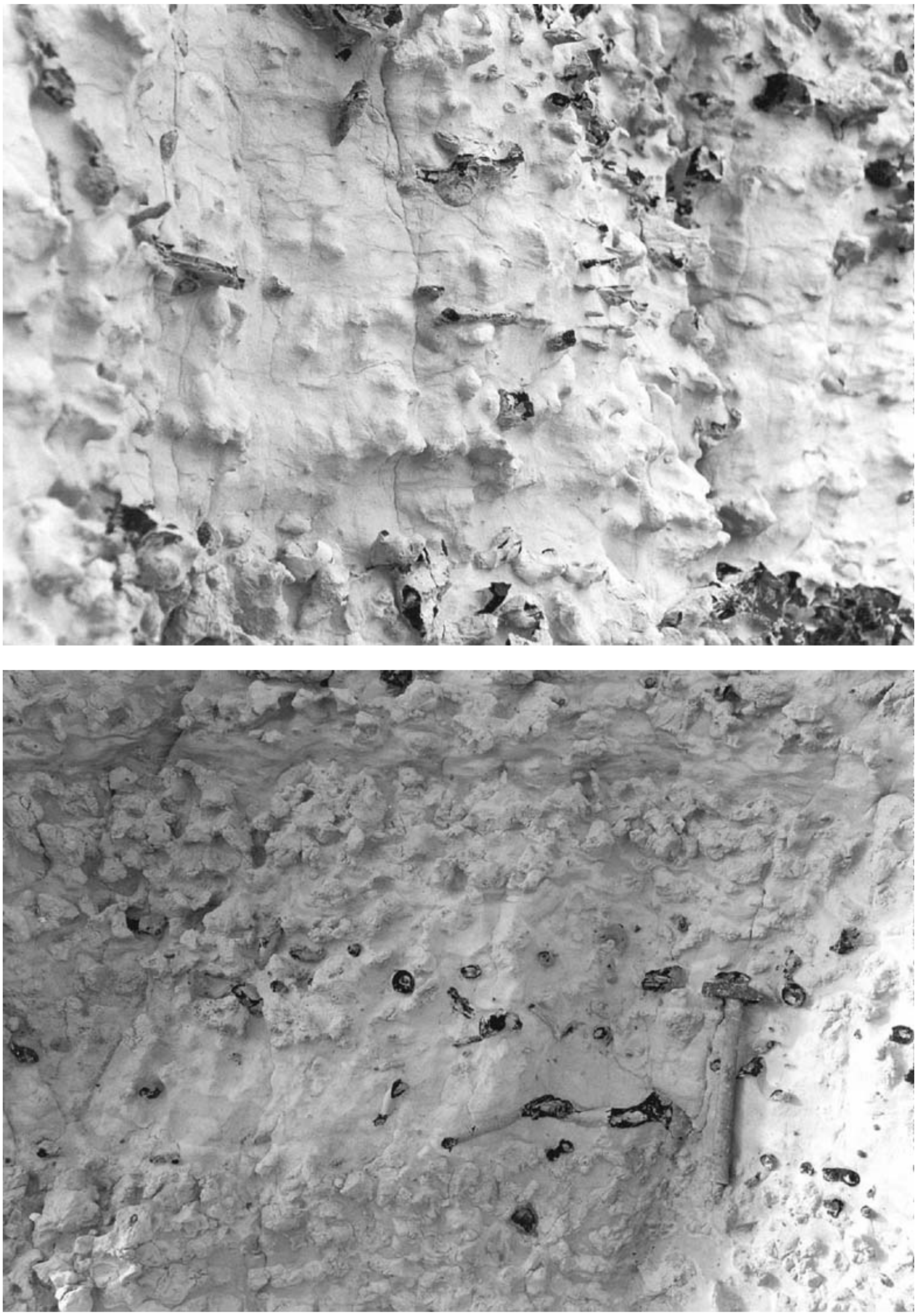

Figure 3.9: (a, b) Basin-wide marker beds in the Upper Turonian part of the Lewes Nodular Chalk Formation present in the Hooken succession at Hooken Cliff. (Photos: R.N. Mortimore.)

Figure 3.48: White Nothe, Dorset, landslipped masses of Chalk and the zig-zag path from the old coastguard lookout (White Nothe Cottages) through the landslipped masses. (Photo: Cambridge University Collection of Aerial Photography: copyright reserved).

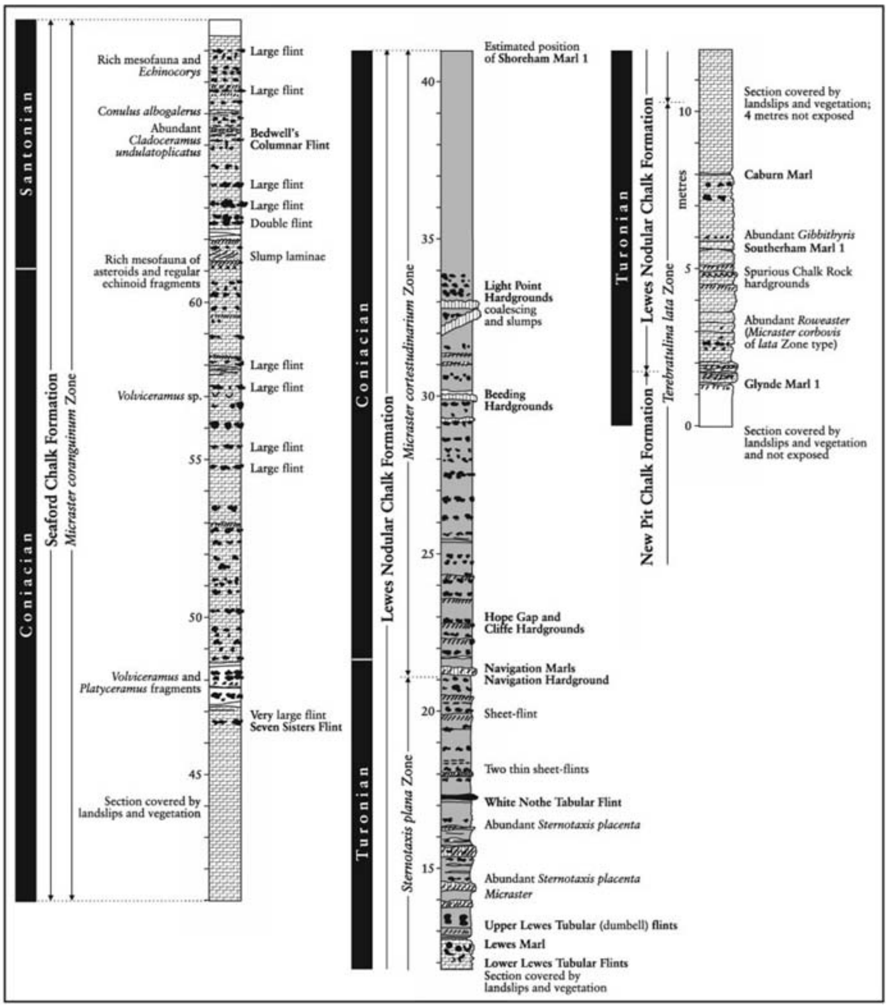

Figure 3.52: Part of the Chalk succession exposed at White Nothe, Dorset, in the slipped masses and in the cliff.

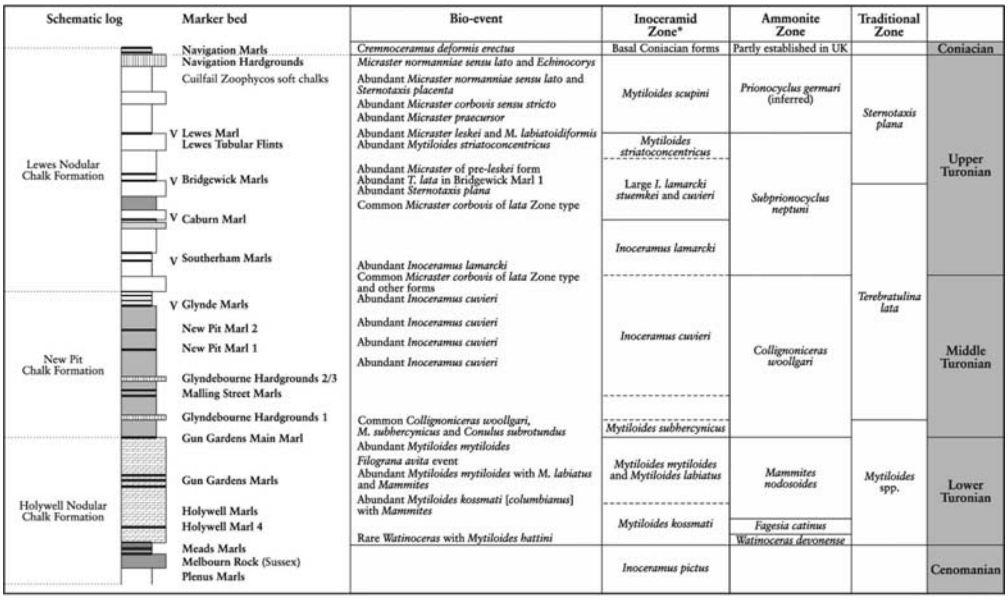

Figure 2.9: Turonian stratigraphy for the onshore UK based on Lewes Pits and Beachy Head, Southern Province. V = marl derived from volcanic ash. (= The inoceramid zones used are transferred from the current scheme used in Northern Europe and are under review.)*

Key basin-wide marker bands in the Seaford Chalk Formation also recognized here include the Belle Tout Marls, Seven Sisters Flint Band and the group of large flints at the Coniacian–Santonian boundary, including Bedwell's Columnar Flint Band (Figures2.21 and 2.22, Chapter 2). As noted in the **Whitecliff** and **Handfast Point to Ballard Point** GCR site reports, many of these latter flints are larger than their equivalents in Sussex and Kent. The abundance of inoceramid bivalve fragments in the Belle Tout Beds of the Seaford Chalk Formation is almost rock-forming at some levels.

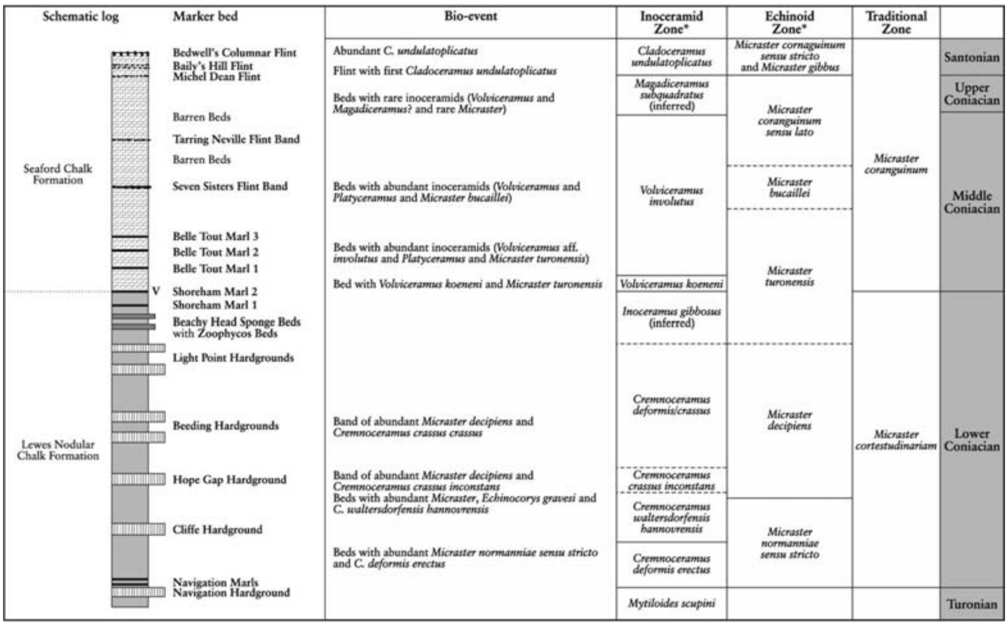

Figure 2.21: Coniacian stratigraphy for the onshore UK based on the Southern Province sections at Lewes, Beachy Head, Seaford Head and Dover. (= informal zones applied in this book; V = vulcanogenic marl.)*

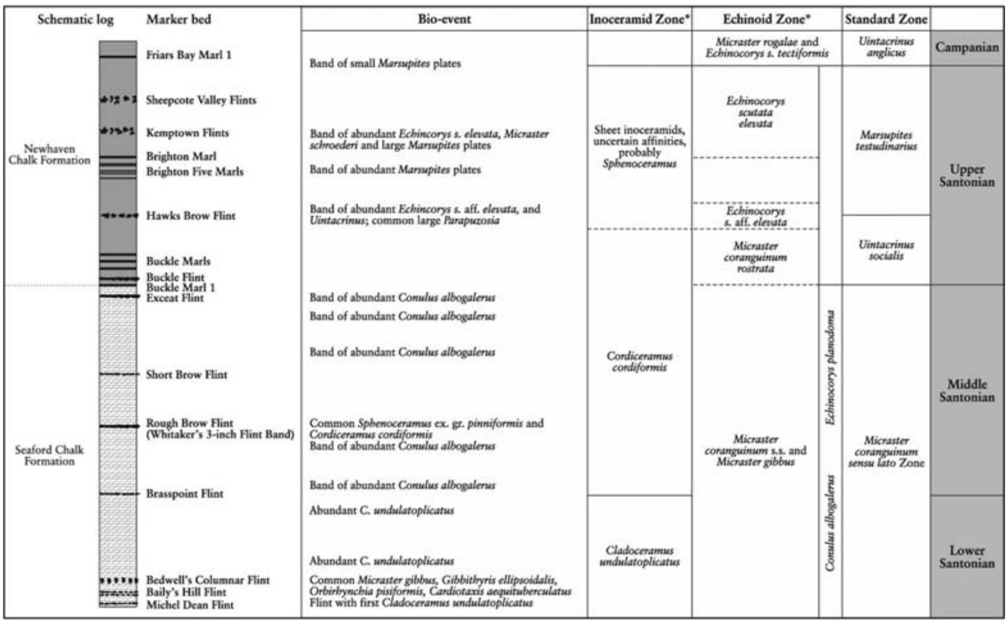

Figure 2.22: Santonian stratigraphy for the onshore UK based on the Southern Province sections at Lewes, Beachy Head, Seaford Head and Dover. (= informal zones applied in this book.)*

Access to the higher parts of the Seaford Chalk Formation and the overlying Newhaven Chalk, Culver Chalk and Portsdown Chalk formations is only possible by rope down the cliffs or by boat to the beach. Rowe (1901) accomplished the latter, and recorded his zones (see below).

Brydone (1914) drew attention to the marl seams that characterize the Newhaven Chalk Formation.

Biostratigraphy

In the absence of good measured sections and properly localized records of key zonal index fossils it is not possible to apply the standard Cenomanian zones to this site yet. The sandy, glauconitic Cenomanian Basement Beds and basal sandy unit of the overlying chalk are found in fallen blocks on the beach and contain abundant fossil echinoids, particularly *Holaster*. Drummond (1967) described the pebbly Cenomanian Basement Beds as rich in derived and *remanié* phosphatized fossils including *Holaster subglobosus* (Leske), *Concinnithyris subundata* (J. Sowerby), *Acanthoceras* sp., *Calycoceras* sp., *Schloenbachia* sp., *Scaphites equalis* J. Sowerby and internal moulds of bivalves and gastropods. Drummond (1967, p. 48), recognized this fauna as representing the ' ...upper beds of the Chalk Marl on the Isle of Wight and the Isle of Purbeck' (i.e. the lower Middle Cenomanian or basal beds of the Zig Zag Chalk around and above the Tenuis Limestone). Much of the Grey (i.e. Zig Zag) Chalk along the south Dorset coast above the sandy basal unit was considered to be poorly fossiliferous by Drummond (1967), yielding only sporadic *Concinnithyris subundata*, *Orbirhynchia wiesti* (Quenstedt), *Holaster subglobosus*, *Terebratulina protostriatula* Owen and *Acanthoceras* sp..

The Plenus Marls Member and the overlying Melbourn Rock and the Meads Marls (as defined in Sussex, see **Southerham Grey Pit** GCR site report, this volume) have yielded the characteristic Upper Cenomanian fossils including the eponymous belemnite and the inoceramid bivalve *Inoceramus pictus* J. de C. Sowerby. Fallen blocks of Lower Turonian Holywell Nodular Chalk yield abundant *Mytiloides*, hence the boundary between the Cenomanian and Turonian stages can be broadly drawn at the change from *I. pictus* to *Mytiloides* in this section. In the big, vertical chalk cliffs within the landslip complex, the Upper Turonian air-weathered Lewes Nodular Chalk is gritty with abundant fossils. *Micraster leskei* Desmoulins is common in and below the Lewes Marl and *Micraster normanniae* Bucaille is found beneath, in and on top of the Navigation Hardgrounds. Typical 'Chalk Rock' brachiopods including *Cretirhynchia minor* Pettitt are present in the nodular chalk equivalents of the Kingston Nodular Beds beneath the Lewes Marl (see Southerham Pit GCR site report, this volume). Of particular note is the abundance of large forms of these brachiopods in beds above the Lewes Marl. Regular echinoids are more common in these beds than at the same horizons in the more basinal settings to the east in Sussex (see also the Handfast Point to Ballard Point GCR site report, this volume). Rowe (1901) was obviously taken with the abundance of weathered-out *Micraster* in this section.

Inoceramid bivalves are abundant in the Lower Coniacian upper Lewes Nodular Chalk Formation but are extremely difficult to collect. It has not proved possible, yet, to confirm the basal Coniacian inoceramid assemblages of the standard succession (Figure 2.21, Chapter 2). However, towards the top of the Lower Coniacian section fragments of large *Cremnoceramus crassus crassus* (Petrascheck) are present in the cross-cutting hardgrounds at the top of the Lewes Nodular Chalk Formation. Towards the base of the Middle Coniacian section the large inoceramid bivalves *Platyceramus* and *Volviceramus* are abundant in the Belle Tout Beds of the Seaford Chalk Formation. The basal Santonian index fossils including *Cladoceramus undulatoplicatus* (Roemer), *Gibbithyris ellipsoidalis* Sahni and *Micraster gibbus* (Lamarck) are well represented in the cliffs adjacent to the coastguard lookout (Seaford Chalk Formation).

Rowe (1901) recorded the Upper Santonian index crinoid fossils *Uintacrinus socialis* Grinnell and *Marsupites testudinarius* (Schlotheim) in the undercliff sections *c*. 100 m east of White Nothe. He also noted the special forms of *Echinocorys*, the nipple-shaped calyx of the crinoid *Bourgueticrinus papilliformis* Griffith and Brydone and the small brachiopod *Terebratulina rowei* Kitchin that are typical of these beds. Beneath Middle Bottom (Figure 3.50), Rowe identified the Lower Campanian *Offaster pilula* horizons and, farther eastwards in this section, he described a 15 ft (5 m) thick bed that yielded 15 specimens of *Actinocamax quadratus* (i.e. *Gonioteuthis quadrata* (Blainville)). Brydone (1914) recognized his *Offaster pilula* Zone here, including his subdivisions based on distinctive forms of *Echinocorys* and the two belts of abundant *Offaster pilula* (see Figure 2.27, Chapter 2; and Newhaven to Brighton GCR site report, this volume, for forms of *Echinocorys* in the Newhaven Chalk Formation).

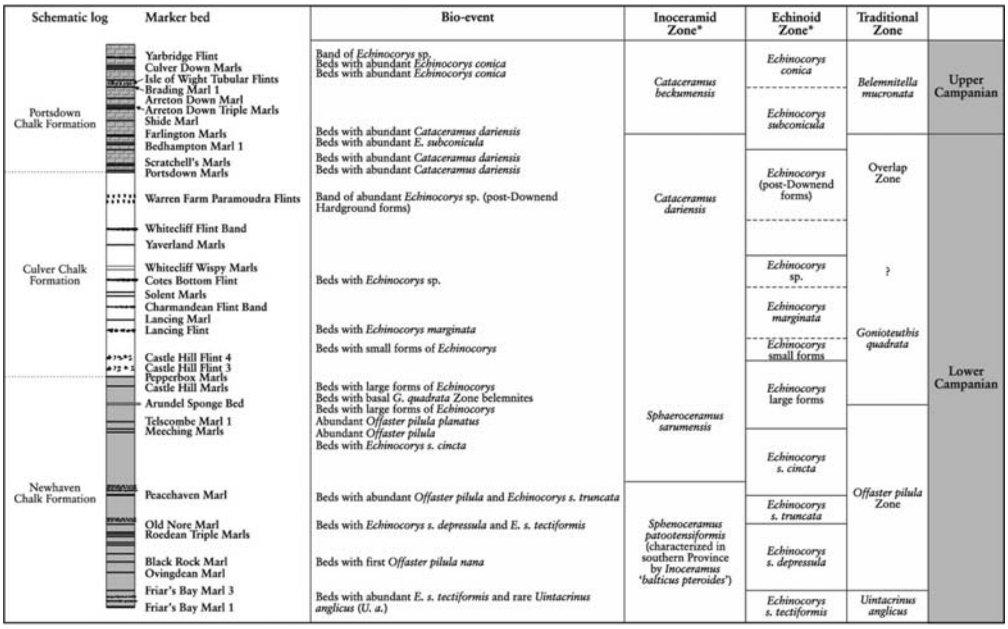

Figure 2.27: Campanian stratigraphy for the onshore UK based on the Southern Province sections at Seaford Head, Portsdown and the Isle of Wight. (= informal zones applied in this book.)*

Interpretation

White Nothe is famous for the Cretaceous ‘overstep' onto older rocks that occurs progressively westwards (e.g. the **Hooken Cliff** GCR site). This overstep is not strictly, however, at the base of the Upper Cretaceous Series, but occurs in the Lower Cretaceous (Albian) Gault. Gault Clay rests on Jurassic strata at White Nothe and Triassic strata at **Hooken Cliff**. The base of the Upper Cretaceous succession does indeed become progressively younger westwards along the south coast of England as the hiatus between the underlying Albian succession and the Cenomanian succession increases. This results in the basal Glauconitic Marl Member being a diachronous deposit, basal Lower Cenomanian in age at Folkestone and Middle Cenomanian in age at White Nothe. Whether this is ‘overstep' or ‘onlap' is a moot point. At White Nothe, and the adjacent sections at Mupe Bay and Lulworth Cove, the Lower Cenomanian deposits are highly condensed, sandy, and glauconitic. Drummond (1967) suggested that the rapid overstep of the Upper Greensand by the Lower Chalk (i.e. Grey Chalk Subgroup) between Mupe Bay and Lulworth Cove indicated severe pre-Grey Chalk Subgroup erosion of the Upper Greensand in the area, emphasizing the disconformity at the base of the Chalk Group. The abundance here of *Holaster subglobosus* in the basal Zig Zag Chalk Formation is a feature of the south-west margin of the basin seen also at **Compton Bay** (see GCR site report, this volume). Similarly, the occurrence of flint in the Zig Zag Chalk on the western margin probably relates to water mass upwelling related to relative ‘highs' along the south-west margin and consequent high organic productivity. Flints are also unusually present in the lower part of the Holywell Nodular Chalk Formation in the Melbourn Rock at Worbarrow Bay and Mupe Bay (Mortimore and Pomerol, 1987).

The possibility that the base of the Lewes Nodular Chalk Formation might rest directly on Holywell Nodular Chalk Formation at White Nothe is also suggested by the section at Mupe Bay (Figure 3.46). Here the basal Lewes Nodular Chalk Formation contains nine green, glauconitic mineralized surfaces (Mortimore, 1979) and the underlying Chalk has the aspect of the Holywell Nodular Chalk Formation. If this is the case it supports the view that the basal Lewes Nodular Chalk Formation is erosional towards tectonic highs, as it is at Antifer-Tilleul, on the equivalent Pays de Caux coast of France. Other erosional channels at the top of the Lewes Nodular Chalk Formation illustrate a similar sedimentary process in the Chalk.

Two major sedimentary processes affecting Chalk stratigraphy are, therefore, illustrated at White Nothe. The first involves condensation and overstep/overlap on the margins of the basin and the second involves major erosional events. The driving forces behind these processes are discussed in Chapter 1. White Nothe also illustrates the influence of basin palaeogeography on the abundance and diversity of chalk faunas. The irregular echinoid*Holaster* is much more common here in the Upper Cenomanian rocks than in correlative sediments in the main part of the basin in Sussex. Likewise, the regular echinoids are much more common here in the Upper Turonian strata.

It is difficult to obtain accurate measurements for much of the Chalk at White Nothe. The high Chalk is, however, cored in the West Lulworth Borehole and this provides a control for that part of the succession (Bristow *et al*., 1997, fig. 6).

Conclusions

White Nothe is a key section for demonstrating the lateral changes that take place in the Upper Cretaceous sediments and fossil assemblages as they are traced from the main basin in Sussex to the margins in south Dorset and south-east Devon. It is a classic area for investigating the sub-Chalk erosion surface and overstep. This is further emphasized by intra-Cenomanian faulting in Mupe Bay. As a transitional area, White Nothe also provides evidence for both continuity and changes in the correlation framework of lithologies, marl seams, flint bands and fossil event horizons in the Chalk of the Southern Province.

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