Hunstanton Cliffs, The Wash, Norfolk

[TF 672 413]–[TF 679 424]

Introduction

The Hunstanton Cliffs GCR site is a west-facing sea cliff, up to 18 m high, that extends 1.3 km NNE from Hunstanton promenade to St Edmund's Point, Old Hunstanton (Figure 5.6). The site provides a continuous, long and beautifully weathered section (Figure 5.7) through the lower two-thirds of the redefined Ferriby Chalk Formation, the equivalent in the Northern Province of the Grey Chalk Subgroup of the Southern Province. This is the first outcrop locality where the stratigraphical terminology of the Northern Province can be applied. The Hunstanton Cliffs GCR site is the next link northwards in the network of GCR sites after Chinnor Chalk Pit in the southern Chiltern Hills and Barrington Chalk Pit (Cambridgeshire). Parts of the succession, notably the basal Paradoxica Bed, the overlying Lower Inoceramus Bed and the Totternhoe Stone are very fossiliferous. The macrofossils from here are critical in the correlation between the relatively condensed successions of the Northern Province and the expanded, basinal successions of the Southern Province. The Ferriby Chalk Formation here, and in the type area, is directly comparable with the Cenomanian successions in northern Germany.

Description

At Hunstanton Cliffs the strata are superbly exposed, and there is a spectacular and dramatic colour contrast between the rusty brown Carstone, the brick-red Hunstanton Red Chalk Formation ('Red Chalk'), and the overall white and grey colours of the Ferriby Chalk Formation (Figure 5.7). A very gentle easterly dip brings the base of the Upper Cretaceous succession to beach level at St Edmund's Point. Between here and New Hunstanton, the Ferriby Chalk is generally inaccessible, except beneath the lighthouse, where it is possible to reach weathered exposures of most of the succession by climbing a former cliff-fall. The various components of the succession can, however, be readily examined in huge fallen blocks on the beach, many of which are sea-washed and reveal sedimentary details that are not easily seen in the cliffs.

The richly fossiliferous nature of the Red Chalk and Ferriby Chalk at Hunstanton Cliffs has attracted the attention of numerous geologists. William Smith included both formations in his 'Table of Strata' (1815a,b) and both were delineated on his map of Norfolk (1819). Early descriptions of the cliffs include those by Taylor (1823), S. Woodward (1833) and Fitton (1836). The most comprehensive account of the stratigraphy of the Ferriby Chalk of the site is given in a British Geological Survey Memoir (Gallois, 1994). Owen (1995) studied the Red Chalk and Jeans (1980) investigated the contact between the Red Chalk and Ferriby Chalk. It was, however, Mitchell (1995a) who identified the extent of the hiatus at the Lower–Upper Cretaceous boundary in the context of the expanded and more complete basinal succession in Yorkshire at Speeton Cliff. Mitchell *et al.* (1996), Gale (1996) and Mitchell and Veltkamp (1997) discussed the correlative succession at Middlegate Quarry and South Ferriby, Lincolnshire.

Lithostratigraphy

The Ferriby Chalk Formation, about 10 m thick (Figure 5.8), extends from the contact with the underlying Hunstanton Red Chalk Formation up to the hard-bed beneath the Nettleton Pycnodonte Marl and overlying Nettleton Stone. Both these markers just fail to be preserved at the top of the cliff adjacent to the lighthouse, but are found in nearby sections inland.

The original lithostratigraphical scheme for the Northern Province (Wood and Smith, 1978) treated the Red Chalk as a member (Hunstanton Chalk Member) of the Ferriby Chalk Formation. Later workers (Whitham, 1991; Mitchell, 1995a; and Owen, 1995) have redefined the Ferriby Chalk by classifying the Red Chalk as a formation in its own right. Owen's revised name, 'Hunstanton Red Chalk Formation', is used in the present volume in accordance with the recent standardized stratigraphical nomenclature.

The pink and cream colours of the thin (up to 0.45 m thick) Paradoxica Bed, at the base of the Ferriby Chalk, contrasts vividly with the red coloration of the Hunstanton Red Chalk Formation beneath, and the grey Lower Inoceramus Bed above. The contact between the Hunstanton Red Chalk Formation and the Paradoxica Bed is extremely complex (Jeans, 1980, fig. 12). Depressions in the eroded top of the Hunstanton Red Chalk Formation are filled by laminated structures, which may be algal stromatolites.

These are overlain by a thin, dark red marl, from which arise laminated columnar structures that are larger than those below. These may also be stromatolites, which would indicate very shallow, possibly intertidal conditions.

The Paradoxica Bed proper comprises several closely spaced, welded, glauconitized hardgrounds, penetrated by sediment-filled, anastomosing *Thalassinoides* burrow systems (Jeans, 1980, fig. 9). It is these complex branching burrows, superbly illustrated by Kennedy (1967, pls 2, 3), and misidentified by 19th century workers as a sponge (*Spongia paradoxica*) that give the name to this distinctive bed. The Paradoxica Bed is divided into two parts at a glauconitized surface. The thinner, upper part, is scarcely preserved in the vicinity of St Edmund's Point, where it is represented by small patches attached to the base of the overlying Lower Inoceramus Bed, but it is an invariable component of the Paradoxica Bed farther to the south, towards New Hunstanton.

The Paradoxica Bed is overlain with an erosive contact by a conspicuously grey coloured bed made up of debris and complete shells of inoceramid bivalves, with a basal concentration of small glauconitized pebbles of hard silty chalk derived from a bed that is otherwise no longer preserved. This shell-detrital sediment, the Lower Inoceramus Bed, is succeeded by a bed of hard, white chalk without any conspicuous shelly material, above which a second erosion surface marks the base of a second, less well-developed unit of inoceramid bivalve shell-detrital chalk, the Upper Inoceramus Bed. This bed contains a weakly glauconitized surface near the base. The beds between here and the Totternhoe Stone include thin marl seams, nodular chalks and manly chalks. The grey-brown Totternhoe Stone forms a conspicuous marker horizon, high in the cliff. The contact is extensively burrowed, with the coarse-grained sediment of the Totternhoe Stone piped down into the underlying chalk for up to a metre in a *Thalassinoides* burrow system. The base of the Totternhoe Stone contains a concentration of glauconitized chalk pebbles and small phosphate clasts. The highest part of the succession can be reached only by means of a ladder, and is not considered further here.

Biostratigraphy

The Ferriby Chalk succession exposed in the Hunstanton Cliffs section extends from the *Neostlingoceras carcitanense* Subzone of the Lower Cenomanian *Mantelliceras mantelli* Zone up to a horizon inferred to be near the base of the Middle Cenomanian *Acanthoceras jukesbrownei* Zone.

The thin marl immediately underlying the Paradoxica Bed, (and representing the highest unit of the Hunstanton Red Chalk), contains a distinctive fauna of small terebratulid brachiopods, associated with the belemnite *Neohibolites ultimus* (d'Orbigny). Some of the brachiopods are forms that were described by d'Archiac (1847) from the basal Cenomanian condensed Tourtia' of the Ardennes in Belgium.

The Paradoxica Bed contains small brachiopods (see Gallois, 1994), the belemnite *Neohibolites ultimus* (d'Orbigny) and the thin- shelled bivalves *Aucellina gryphaeoides* (J. de C. Sowerby *non* Sedgwick) and *A. uerpmanni* Polutoff It is extremely difficult to extract fossils from these indurated chalks. The *Aucellina* range up to the glauconitized erosion surface that divides the Paradoxica Bed into two. The higher unit contains large terebratulid brachiopods (*Tropeothyris?*) and *Inoceramus* ex gr. *crippsi* Mantell. The occurrence of *Aucellina* and *Neohibolites ultimus* allows the Paradoxica Bed to be correlated with the basal Cenomanian *ultimus/Aucellina* event recognized in northern Germany (Ernst *et al.,* 1983; Ernst *et al.,* 1996, fig. 5). Although the index ammonite has not been recorded, the identification of this event allows the Paradoxica Bed to be assigned to the *Neostlingoceras carcitanense* Subzone.

The Lower Inoceramus Bed is largely composed of fragmented and complete shells of *Inoceramus crippsi* Mantell. The small echinoid *Holaster bischoffi* Renevier is common at the base, and the bed contains a diverse fauna of serpulids, brachiopods, bivalves and echinoids (Gallois, 1994). Small ammonites, including *Schloenbachia,* are found as poorly-preserved glauconitized pebble-fossils at the base, and larger ammonites occur in the middle of the bed.

Noteworthy components of the fauna are rare *Neohibolites ultimus* and the ornate oyster *Rastellum colubrinum* (Lamarck), which is quite common. The occurrence of *Inoceramus crippsi* in flood abundance, associated with *R. colubrinum* (Lamarck) and a single specimen (A.S. Gale, pers. comm., 1999) of *Sharpeiceras schlueteri* Hyatt, places this bed in the *schlueteri* Subzone of the *Mantelliceras mantelli* Zone.

The Upper Inoceramus Bed mostly contains thinner-shelled inoceramid bivalves of the *Inoceramus crippsi* group such as *I. crippsi hoppenstedtensis* Trager. A glauconitized surface near the base (the 'Turrilitoid Plane' of Jeans, 1980), overlain by very large and poorly preserved, glauconitized heteromorph ammonites (*Hypoturrilites* and/or *Mariella),* can be followed from here to Yorkshire, and is probably equivalent to the *Mariella* event recognized throughout northern Germany (Ernst and Rehfeld, 1997). This re-appearance of coarse, shell-detrital chalks in Hunstanton Cliffs and correlative Northern Province sections, is now considered to correspond to the coarser chalks with associated phosphates that mark the base of the *Mantelliceras dixoni* Zone in southern England (see (Figure 5.9)). This interpretation, which has recently been applied to the Speeton Cliff section (Mitchell *et al.,* 1996, fig. 5), is supported by the entry of *Inoceramus virgatus* Schlüter in the succeeding nodular chalks, corresponding to the ubiquitous acme-ocurrence of this species in the lower part of the *dixoni* Zone.

The beds below the Totternhoe Stone contain specimens of the small rhynchonellid brachiopod *Orbirhynchia mantelliana* (J. de C. Sowerby), bivalves including *Limea* sp., and a diverse echinoid fauna. This brachiopod occurrence (Orbirhynchia Band 1 of Jeans, 1968) equates with the lowest of the three *Orbirhynchia mantelliana* bands developed in the Southern Province (e.g. at Folkestone; see (Figure 5.9)) and, together with the *virgatusacme* beneath, unequivocally establishes the correlation between the two areas at this level. This event bundle can be readily traced northwards from here to the Melton Bottom Chalk Pit and Flamborough Head (Speeton Cliff) GCR sites. The terminal Lower Cenomanian *Mantelliceras dixoni* Zone appears to be truncated by the sub-Totternhoe Stone erosion surface, since there is is no evidence here for the basal Middle Cenomanian *Cunningtoniceras inerme* Zone.

The Totternhoe Stone here is very fossiliferous, and excellent collections can be made from fallen blocks between the lighthouse and St Edmund's Point, particularly from those that have fallen upside down to reveal the basal fossil concentration. The rich brachiopod and bivalve faunas are those of the Cast Bed of the southern England basinal facies. *Entolium orbiculare* (J. Sowerby) and *Oxytoma seminudum* Dames occur in profusion, together with numerous serpulids, including the distinctive noded tube, *Glandifera rustica* J. Sowerby, and the small brachiopods *Grasirhynchia martini* (Mantell), *Kingena concinna* Owen and *Modestella geinitizi* (Schloenbach). Compared with the three-dimensionally preserved phosphatized steinkerns at the base of the Totternhoe Stone in the Chiltern Hills, the ammonites here, such as *Acanthoceras* sp., are rather poorly preserved as flattened and weakly glauconitized composite moulds. The belemnite *Praeactinocamax primus* (Arkhangelsky), which occurs rarely at this level in the Southern Province, for example at Southerham Grey Pit, and, more commonly, in the Chiltern Hills, (e g Chinnor Chalk Pit), is accompanied here by the diminutive aberrant form, *Belemnocamax boweri* Crick. This latter form, which is a typical Northern Province species (Crick, 1910a; Christensen, 1992), has so far not been recorded south of Hunstanton. This faunal assemblage, particularly the two belemnites, characterizes the key northern European *primus* event (Ernst *et al.,* 1983; Christensen, 1990; and (Figure 2.12) and (Figure 2.13), Chapter 2), which has been shown by stable isotope data (Mitchell *et al.,* 1996, Paul *et al.,* 1994) possibly to mark a short-term cooling phase in early Mid-Cenomanian times.

The Totternhoe Stone is overlain by a hard white chalkstone, the Ammonite Bed', which contains large, uncrushed and weakly glauconitized ammonites, including *Parapuzosia (Austiniceras) austeni* (Sharpe). The occurrence of *Orbirhynchia mantelliana* establishes the correlation between this bed and the topmost of the three *Orbirhynchia mantelliana* bands in southern England, and with the fauna of the higher part of the type Totternhoe Stone of the Chiltern Hills. By analogy with sections in the Southern Province, this bed marks the top of the *Turrilites costatus* Subzone. The occurrence of *Austiniceras* here finds a parallel in northern Germany, where the *primus* event is followed by a horizon with common *Austiniceras* and *Holaster subglobosus* (Leske), associated with the condensation marked by the so-called 'mid-Cenomanian Event' (Ernst *et al.,* 1983, 1996).

There is no biostratigraphical evidence to prove the existence of the overlying *Turrilites acutus* Subzone, but it can be inferred, on general stratigraphical grounds, to be present in the interval between the Ammonite Bed and the Nettleton Stone.

Interpretation

Compared to the succession in the Flamborough Head GCR site at Speeton Cliff, where there is an apparently unbroken sedimentary record across the Albian–Cenomanian boundary, there is a significant hiatus between the Hunstanton Red Chalk Formation and the Ferriby Chalk Formation at Hunstanton Cliffs. At Speeton Cliff the equivalent of the Paradoxica Bed is separated from the extrapolated base of the Cenomanian Stage by nearly 6 m of red sediments, including marls, marly chalks and chalks with marl flasers (see Flamborough Head GCR site report, this volume) belonging to the Hunstanton Red Chalk Formation. The top of this succession, 1.3 m of alternating thin marls and marly chalks, equates with the thin dark red marl beneath the Paradoxica Bed at Hunstanton, and rests on a deeply burrowed erosion surface. In contrast to Speeton Cliff the entire succession below this erosion surface down to the extrapolated base of the Cenomanian Stage is missing at Hunstanton. Hence the low, but certainly not basal, Cenomanian Paradoxica Bed rests here with major hiatus on a level in the Upper Albian (*Stoliczkaia dispar* ammonite Zone) Hunstanton Red Chalk Formation (cf. Mitchell, 1995a, fig. 12; and (Figure 5.8)).

The Paradoxica Bed, when traced southwards from Hunstanton Cliffs in cored boreholes, thickens and becomes progressively less indurated, passing into buff-coloured chalks known as the Torcellaneous Beds' (Morter and Wood, 1983). These beds contain few fossils apart from *Aucellina,* which, as in the Paradoxica Bed and in the equivalent unit (Crowe's Shoot Member) at Speeton Cliff; range up to a surface above which there are no further records. The higher part of the unit contains specimens of *Inoceramus* cf. *comancheanus* Cragin and poorly preserved chalky moulds of ammonites, including *Mantelliceras, Schloenbachia* and heteromorphs such as *Algerites.* The occurrence of the heteromorphs supports the assignment of the condensed equivalent of this bed at Hunstanton to the *carcitanense* Subzone.

The lower part of the Ferriby Chalk Formation, from the base of the Paradoxica Bed up to the base of the Totternhoe Stone, is extremely condensed at Hunstanton Cliffs (5.8 m) and in the nearby Hunstanton Borehole (6.3 m), in comparison with its development at Middlegate Quarry, South Ferriby (10.5 m), Melton Bottom Chalk Pit (9.8 m) and Speeton Cliff (Flamborough Head GCR site; 20.3 m) to the north (see (Figure 5.9)). It is also very thin compared with the same interval at Barrington Chalk Pit (27 m in Jeans, 1980, fig. 1). The succession from the Totternhoe Stone to the sub-Plenus erosion surface is also much thinner at Hunstanton Cliffs than in the sections to the north. However, the proportional thinning is less, and the interval between the Totternhoe Stone and the Nettleton Stone retains a similar thickness, albeit increased by about 1 m only in the correlative sections.

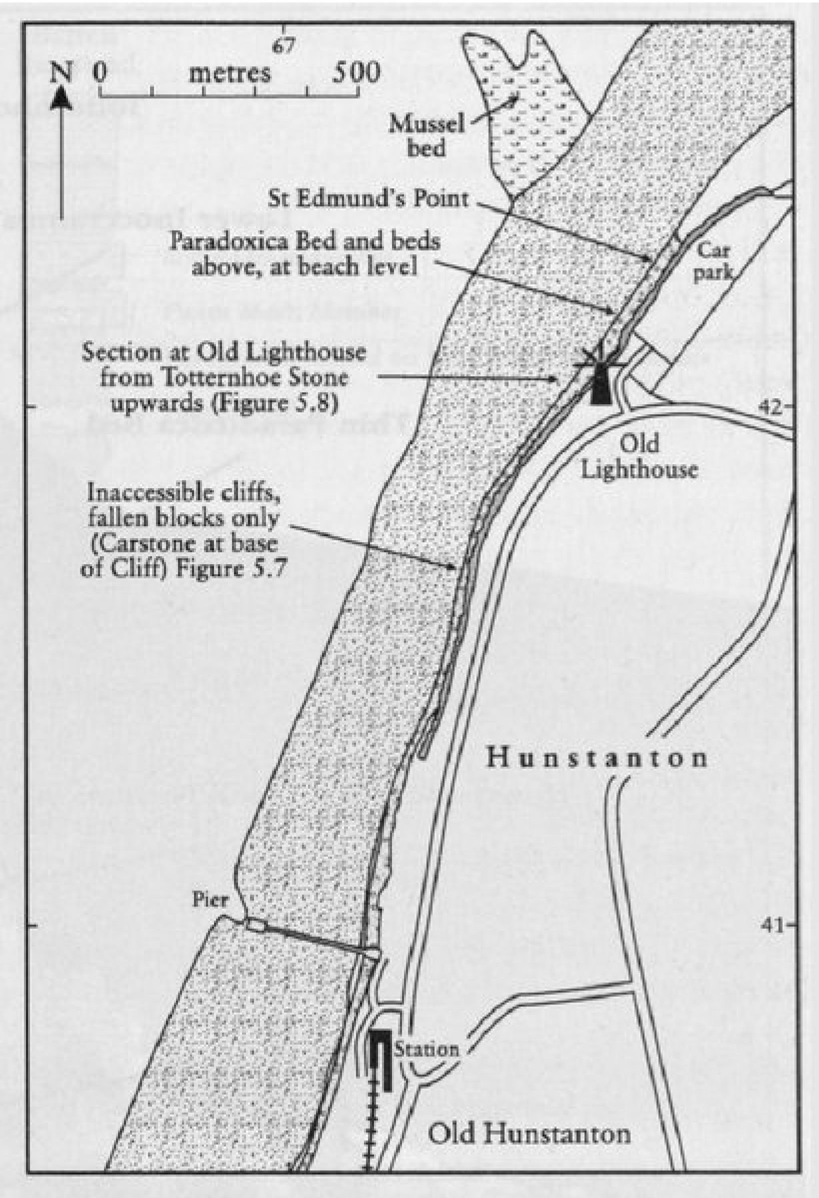
Compared to the more complete Lower–Middle Cenomanian boundary transition at Speeton Cliff the Hunstanton Cliffs section is significantly condensed, with the equivalent of the basal Middle Cenomanian *Cunningtoniceras inerme* Zone of the Southern Province completely missing at the hiatus marked by the sub-Totternhoe Stone erosion surface. In this respect the Hunstanton Cliffs succession is comparable with those at Middlegate Quarry, South Ferriby (cf. Mitchell et al., 1996, fig. 3) and at Melton Bottom Chalk Pit. The sub Totternhoe Stone erosion surface in these platform successions, including those discussed earlier in the Chiltern Hills sections, for example Chinnor Chalk Pit, represents a sequence boundary located at a very high level in the terminal Lower Cenomanian *Mantelliceras dixoni* Zone. The hiatus between the Hooken Member (Bed A2) and the Little Beach Member (Bed B) in the highly condensed Beer Head Limestone Formation succession of south-east Devon also corresponds to this sub Totternhoe Stone hiatus (see Hooken Cliff GCR site report, this volume). In the basinal successions, such as those found at the Southerham. Grey Pit and Folkestone to Kingsdown GCR sites, there is no erosion surface at this level, and the sequence boundary is marked merely by a sudden increase in clay content of the sediment up-section.

The upward continuation of the Hunstanton Cliffs section can be found in several small, now degraded, pits and quarries in the vicinity of Hunstanton, and in the area immediately to the south (Gallois, 1994, fig. 39). The succession from the Nettleton Stone upwards at the Barrett Ringstead Chalk Pit [TF 6892 4003] is shown on (Figure 5.8). The hiatus at the base of the Hunstanton Red Chalk Formation develops eastwards into Norfolk. The Red Chalk at Hunstanton rests on Lower Cretaceous Carstone, whereas in the British Geological Survey Trunch Borehole (Wood *et al.,* 1994) it rests on Jurassic (Lias) sediments.

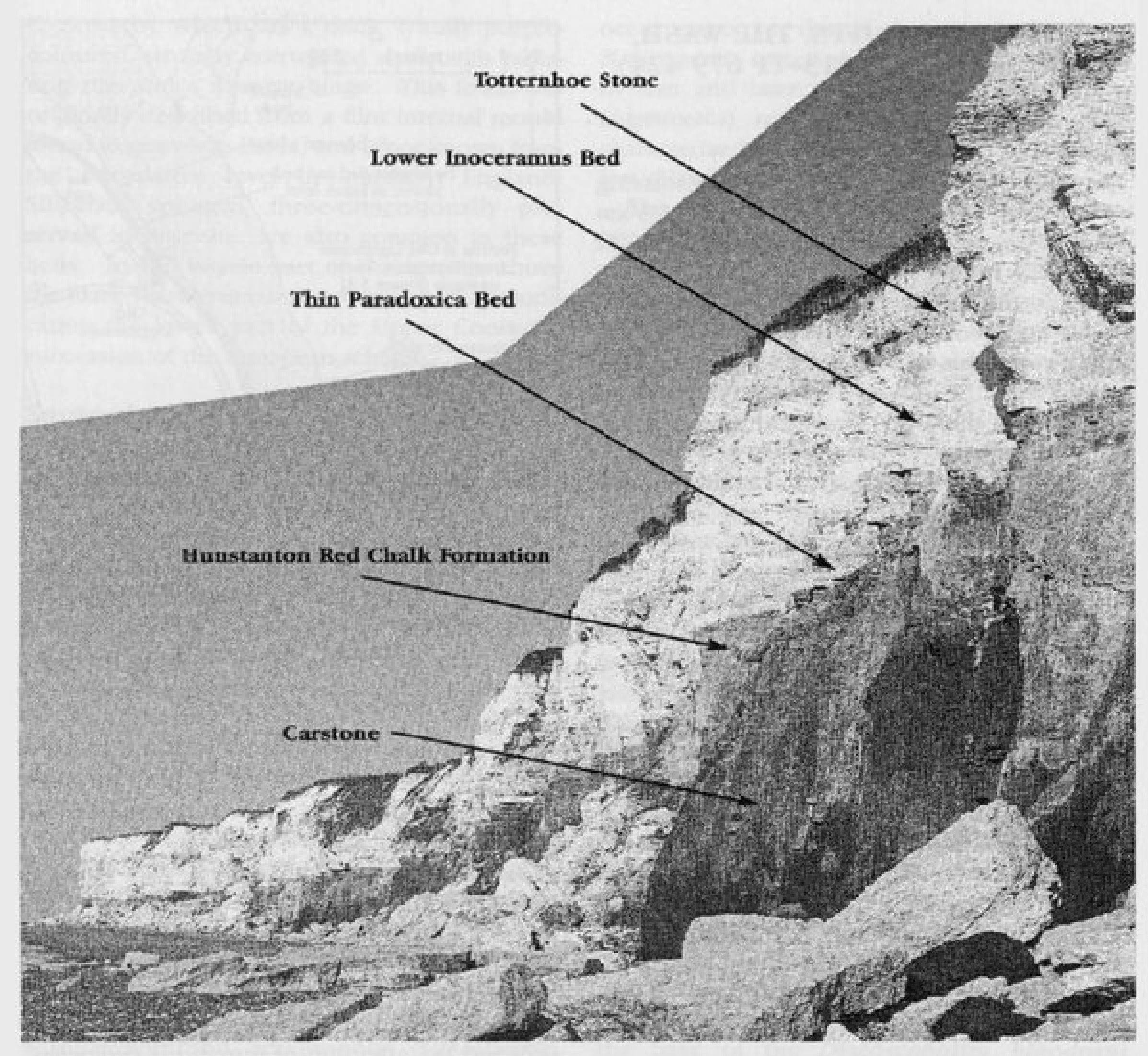
Conclusions

Hunstanton Cliffs, located at the southern margin of the Northern Province, provides a vital link between the Chalk provinces of England. It is the type locality for the Hunstanton Red Chalk Formation, a mapping horizon at the base of the Chalk escarpment northwards through Lincolnshire and Yorkshire, and a marker bed in the North Sea. Because of its location on a tectonic high beneath the Wash there are marked erosional hiatuses at the base of the Cenomanian succession between the Hunstanton Red Chalk Formation and Ferriby Chalk and beneath the Totternhoe Stone: The Plenus Marls Member in adjacent quarry exposures is also highly condensed, resting on a strongly developed sub-Plenus erosion surface. These erosion surfaces relate to sequence boundaries that can be traced into thicker, more complete, sections at the Flamborough Head (Speeton Cliff) GCR site, in the Northern Province and the Folkestone to Kingsdown and Southerham Grey Pit GCR sites in the Southern Province.

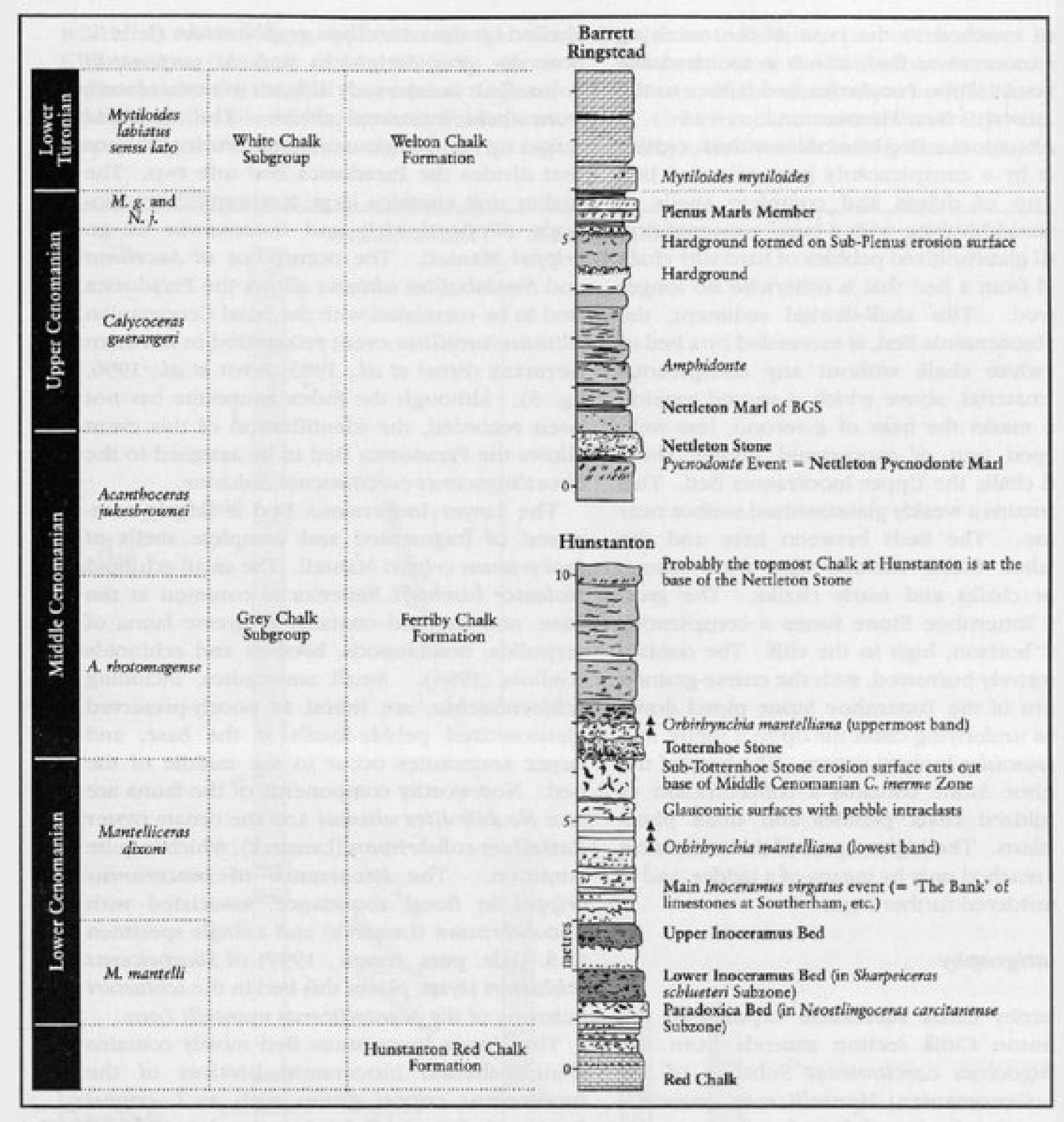
[References](#)



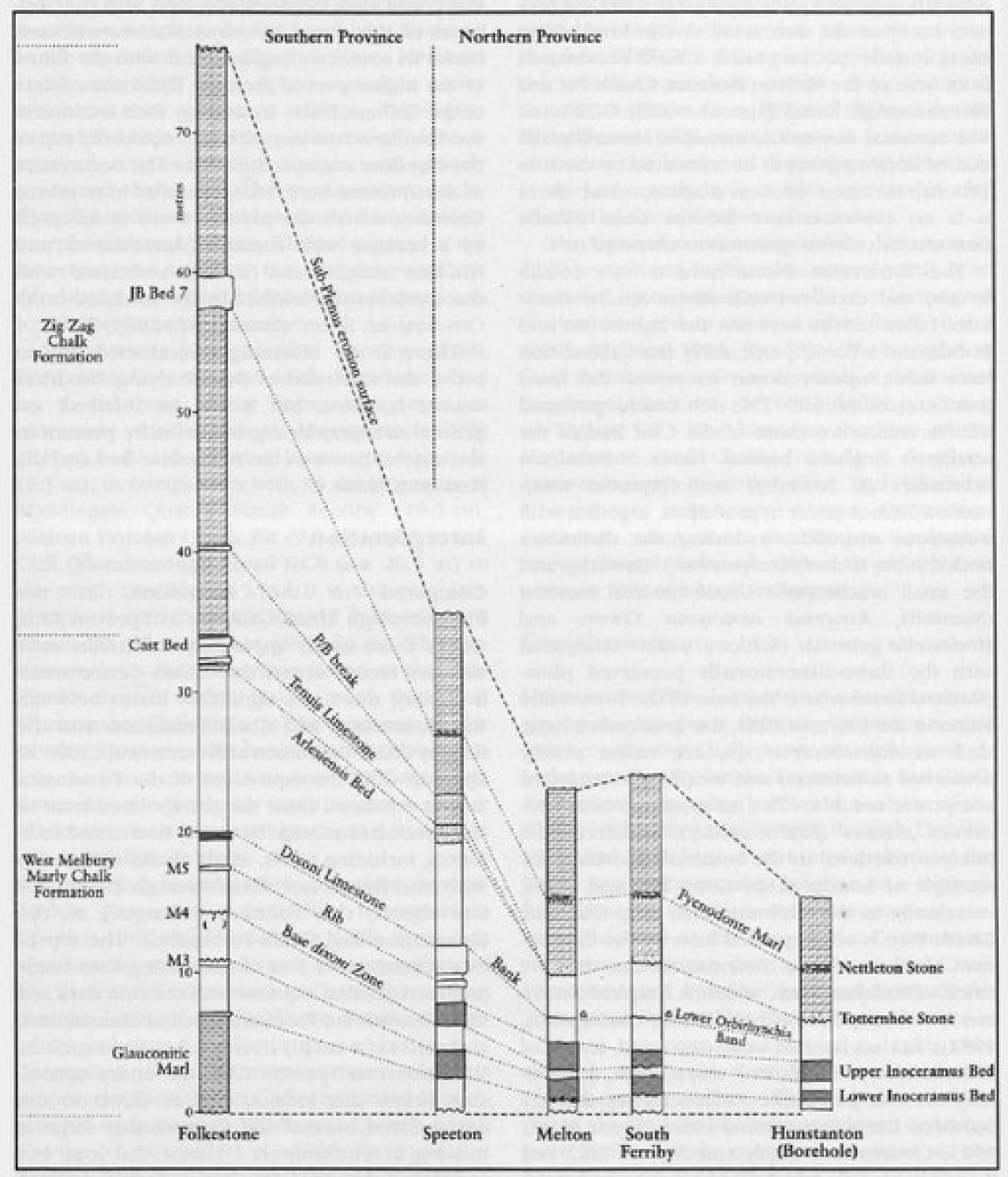
(Figure 5.6) Map of the Hunstanton Cliffs GCR site (also see (Figure 5.7)).



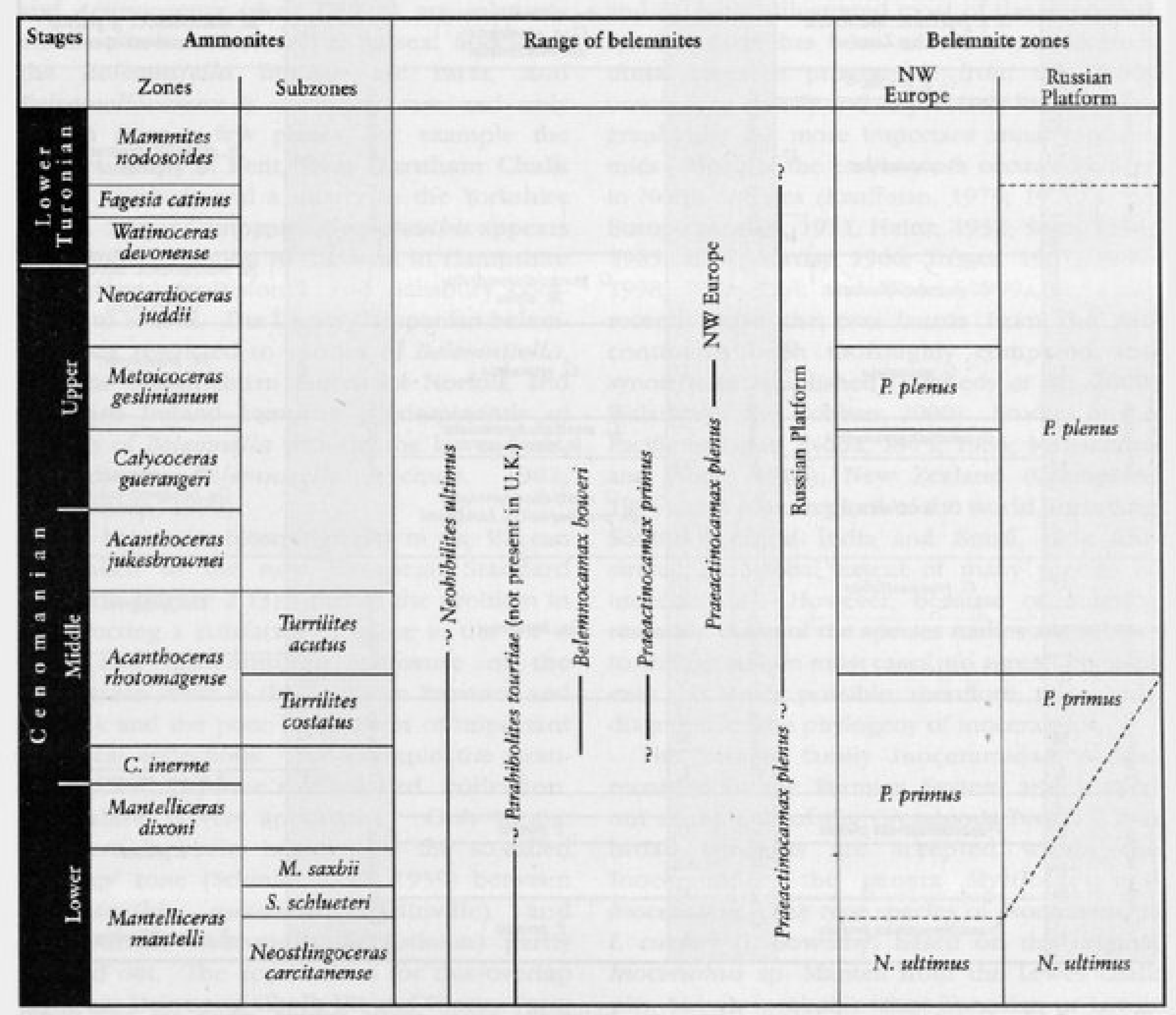
(Figure 5.7) Hunstanton Cliffs, north Norfolk coast. (Photo: A. Hutchinson.)



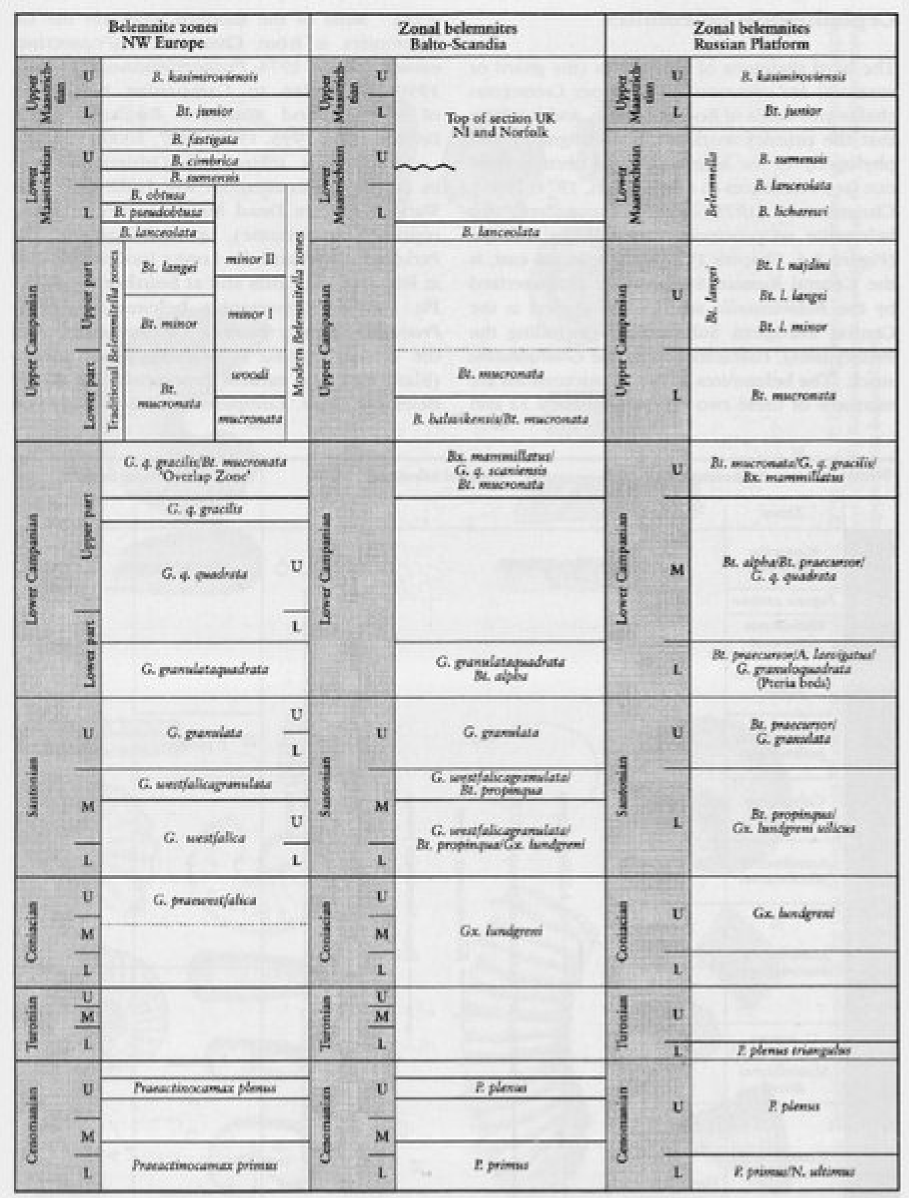
(Figure 5.8) The Chalk succession at Hunstanton Cliffs (compare with (Figure 5.7)). The higher Cenomanian beds are not present at Hunstanton, these are seen at Barrett Ringstead Chalk Pit. (M. g. = Metoicoceras geslinianum; N. j. = Neocardioceras juddii.)



(Figure 5.9) Correlation of key marker beds in the Cenomanian Grey Chalk Subgroup between the Southern Province (West Melbury Marly Chalk and Zig Zag Chalk formations), and the Northern Province (Ferriby Chalk Formation).



(Figure 2.12) Comparison between the ranges of Cenomanian belemnites on the Russian Platform and in northwest Europe. (After Christensen, 1990.)



(Figure 2.13) Comparison of Upper Cretaceous belemnite zones across Europe, which are only partly represented in the UK and mainly on the Anglo-Brabant Massif. (After Christensen, 1991.) (A. = Actinocamax; B. = Belemnella; Bt. = Belemnitella; Bx. = Belemnellocamax; G. = Gonioteuthis; Gx. = Goniocamax; N. = Neohibolites; P. = Praeactinocamax.)