DOWNEND CHALK PIT

OS Grid Reference: SU601065

Introduction

Downend Chalk Pit is a largely backfilled former large Chalk quarry on the south side of the western end of Portsdown Hill (Figures 3.75–3.79), adjacent to the M27. The site comprises two sections. The first, on the north side of the site, consists of a 3–4 m high cliff-cut along an old access road, which exposes a section near the base of the Portsdown Chalk Formation containing marl seams and abundant inoceramid bivalve shell-debris in the lower part of the *Belemnitella mucronata* Zone (Upper Campanian). The second section, which is stratigraphically below the first section, and 50 m to the south, is a north–south, 20 m high, west-facing, vertical face containing some of the original special features of the pit. This second section is part of the original excavation, but landfill, with a steep 70º – 80º face, has left only a narrow gully along the base of the chalk cliff. There is no easy access to the old chalk face and a track has to be beaten down the steep landfill slope through the undergrowth.

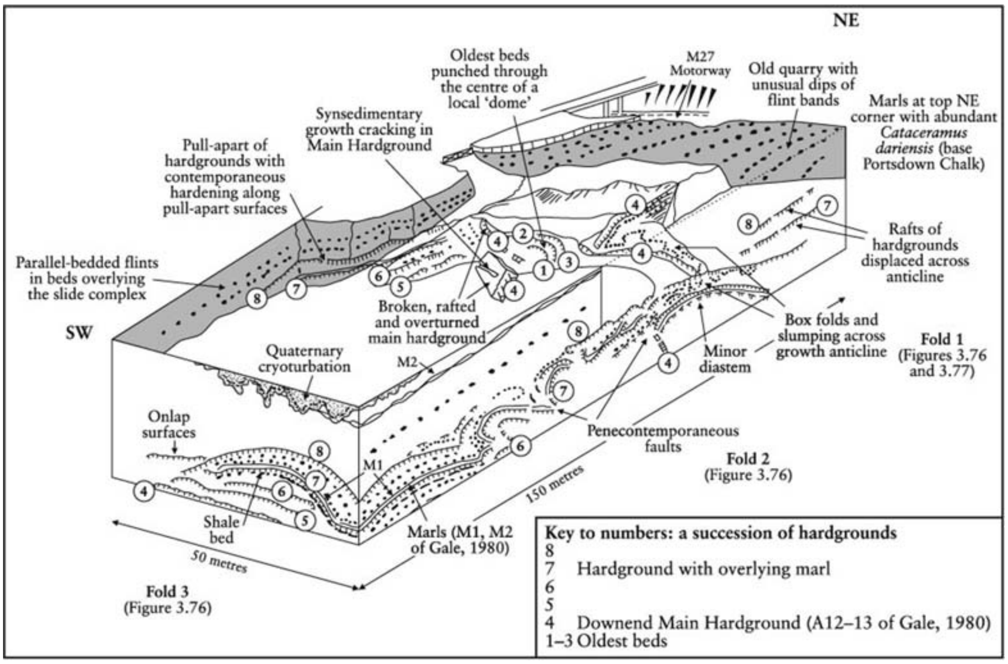


Figure 3.75: Sketch of the geology of the Culver Chalk Formation formerly exposed in Downend Chalk Pit, Portsdown. Hardgrounds, growth structures and slumps are interpreted as resulting from latest Early Campanian Peine Phase tectonic uplift. (From Mortimore, 1979, 1983; and Gale, 1980).

Downend Chalk Pit is unique in two particular aspects of Chalk stratigraphy and sedimentology. First, there is the spectacular evidence for the intra-Chalk movements represented by growth of sedimentary mounds and box-folded flints in the lower part of the exposure. These slump beds are overlain by parallel-bedded, undisturbed layers of flint and chalk, indicating a stratigraphically distinct period of movement in late Early Campanian times. The second key feature is the exposure of beds of the *Gonioteuthis quadrata* Zone and the overlying mixed assemblage of *G. quadrata* and *Belemnitella mucronata* of the belemnite 'Overlap Zone' at the top of the Lower Campanian strata (Figure 2.27, Chapter 2). Nowhere else in the UK has this level been so well exposed to study and the palaeontological evidence from this site has been vital in establishing the biostratigraphy of the 'Overlap Zone' and its correlation with successions in northern Germany.

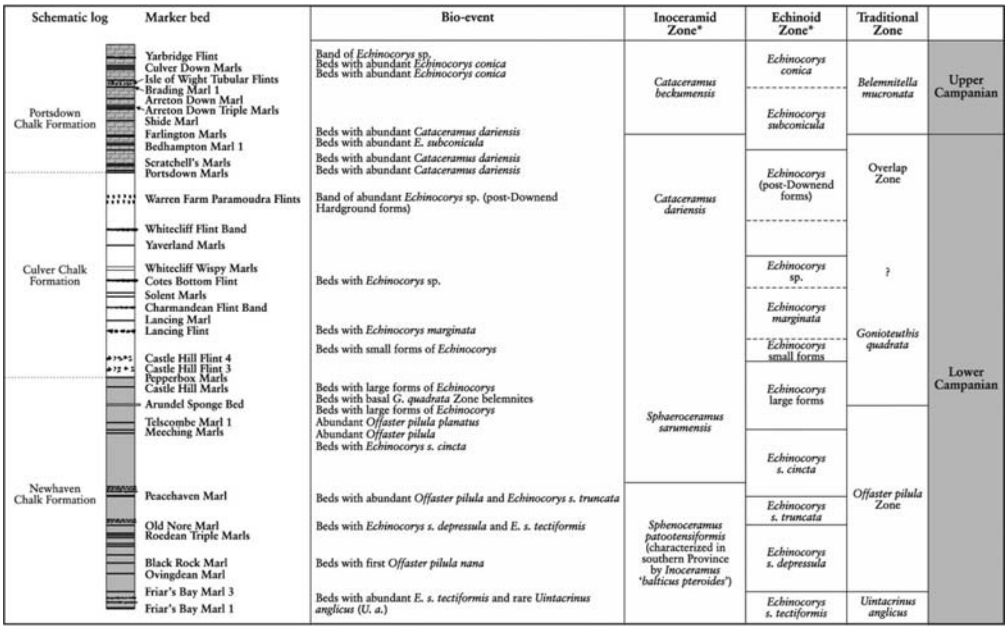


Figure 2.27: Campanian stratigraphy for the onshore UK based on the Southern Province sections at Seaford Head, Portsdown and the Isle of Wight. (= informal zones applied in this book.)*

Description

The earliest descriptions of Downend Chalk Pit (Brydone, 1912; White, 1913, p. 29) reported anomalous bedding dips in the *Gonioteuthis quadrata* Zone and *Belemnitella mucronata* Zone Chalk. Brydone (1912) referred to this locality as 'Rogers Whitening Pit' and gave it the Hampshire locality number 1153. White (1913) suggested that the anomalous dips could not be explained by the normal tectonic folding that produced the Portsdown Anticline. Subsequent work (Gale, 1980; Mortimore, 1979, 1983, 1986a,b; Mortimore and Pomerol, 1991a, 1997) has illustrated the sedimentological character of the Downend chalk, which contains intraformational slumping, very rare in onshore exposures of Chalk in England (see also the Boxford Chalk Pit GCR site report, this volume). These sedimentary structures are exposed on the eastern wall of the pit. Also, unique to England, are the ammonites found in, on and above the Downend Main Hardground (Gale, 1980). These fossils are a critical link in the correlation of the Campanian successions between North America and Europe.

Lithostratigraphy

The first published detailed descriptions of Downend Chalk Pit were by Gale (1980) when the pit was still being worked for lime. He identified three lithological groups of beds lettered A to C. Gale placed the boundary between his A and B Beds along the top surface of the most conspicuous of many hardgrounds, a composite surface, which he designated A12–13. The A Beds were generally free of flint and comprised a series of glauconitized green-coated hardground surfaces. Both the thickness and biostratigraphy of these beds were poorly constrained because they were caught up in the intraformational slump folding.

In contrast to the A Beds, the B Beds contained numerous bands of flint and less well-developed ferruginous hardgrounds and glauconitized erosion surfaces. A marl seam, the Lower Downend Marl, occurred just above one of the glauconitized surfaces. The basal marker to the C Beds at the top of the pit was the Upper Downend Marl, overlain by soft chalk with marly wisps and a few flints.

Gale (1980) identified two phases of intra-Chalk folding, the first after the A Beds had formed but before the B Beds were deposited, leading to dislocation and rafting of the A12–13 hardground. A second phase of folding, following deposition of the Bed B4, led to further brittle fracturing of A12–13 and disruption of the B Beds up to B4.

In an unpublished thesis (Mortimore, 1979, pp. 70–3, 166), the Downend succession was divided into Lower Beds and Upper Beds (Figure 3.78). The Lower Beds consisted of 16 mineralized hardgrounds or surfaces with few flints, comprising Gale's (1980) A Beds and the B Beds up to B4. The Upper Beds, with few mineralized surfaces and abundant flint bands, included all the chalk above the slump-folded and disturbed part of the sequence (i.e. above Gale's B4 hardground). In this description (Mortimore, 1979), Gale's strongly lithified composite surface (A12–13) was named the 'Downend Main Hardground', and the surface B4 the 'Upper Downend Hardground'. The Lower Downend Beds comprised six cycles divided by the most obvious hardground surfaces or groups of hardgrounds. The 'Downend Marl' of Mortimore (1979) is the same as the 'Lower Downend Marl' of Gale (1980). In addition, Mortimore identified a shaly-chalk bed beneath the hardground labelled 7 (see Figures 3.75 and 3.76), and provided a block diagram of the Downend Chalk Pit exposures as they were seen in 1977. Further section details were published by Mortimore (1983, 1986a,b), in which the Downend succession was divided into the Culver Chalk (Member) below, and Portsdown Chalk (Member) with marl seams above. Some correlations of the marl seams at Downend with those at Farlington, Portsdown and **Whitecliff**, Isle of Wight, were suggested.

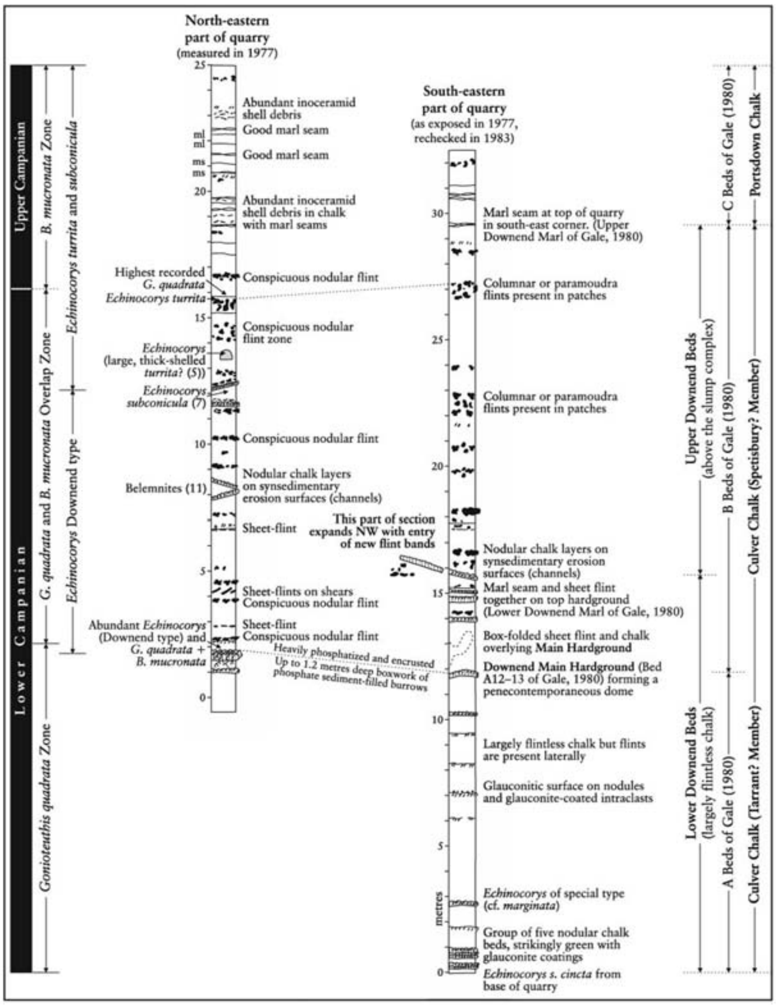


Figure 3.78: Stratigraphy of the Campanian Chalk originally exposed at Downend Chalk Pit, Portsdown. Any two sections are different as synsedimentary channels and growth of penecontemporaneous slump folds create local pockets of expanded or condensed sediments. The sections shown are an attempt to illustrate the total range of the stratigraphy and the main subdivisions unravelled from the slump complex. (ms = marl seam; ml = marly laminae.)

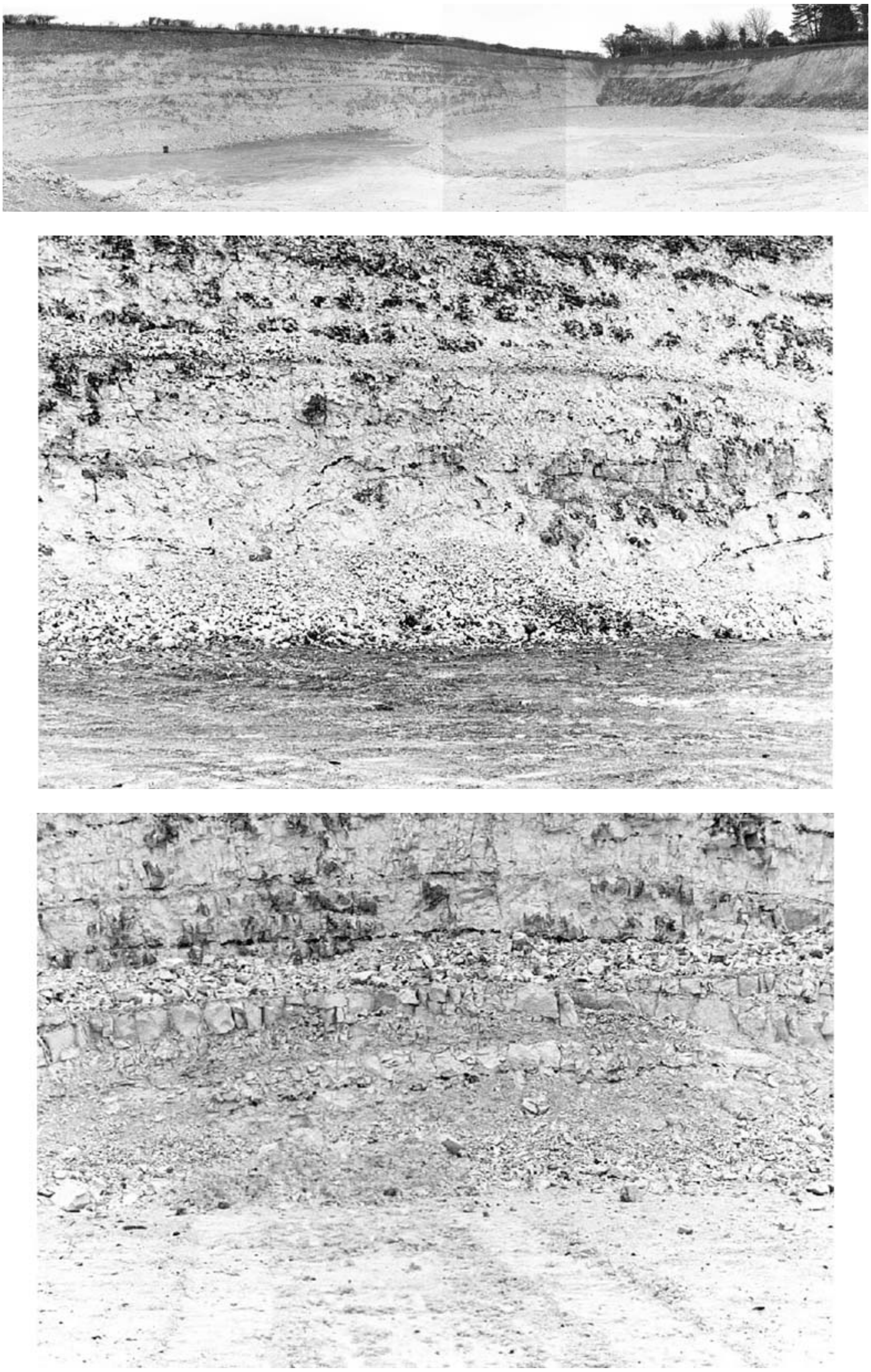


Figure 3.76: Downend Chalk Pit, Portsdown, Hampshire, looking east onto the eastern and southern faces. Growth tectonics, synsedimentary slumping and penecontemporaneous slump folding in the intra-Early Campanian Culver Chalk Formation. (a) Box-folded flint band over the Downend Main Hardground (4). (b) Detail within Fold 2; slump folding. (c) Detail within Fold 3; a hardground succession. (Photomosaic: R.N. Mortimore.)

The Downend Main Hardground (Mortimore, 1979, 1986a; bed A12–13 of Gale, 1980) formed a spectacular, undulating surface, strongly mineralized by glauconite and phosphate, and encrusted by large oysters. Hard, cemented chalk extended down 0.7 m below the surface of the hardground. Detrital phosphate and coarse chalk filled a branching network of

Thalassinoides burrows, which extended to 2 m below the surface. Huge blocks of this hardground formed scattered rafts across the floor of the pit, lying at various angles and even overturned in soft white chalk. Critical observations included the evidence of cracking and pull-apart of the hardground while it was forming. The broken and split edges of the hardground were mineralized and bored like the top surface.

The Downend Main Hardground acted as a marker bed for tracing the complex system of intraformational folds through the pit. Generally, the hardground either buckled into open folds or cracked apart, and disrupted elements separated and rafted away. In contrast, the more plastic overlying beds, containing a conspicuous nodular flint band, formed much tighter and more complex box-folds. Within these beds was a well-developed marl seam named by Gale (1980) the 'Lower Downend Marl' (Figure 3.78).

Within the exposure, intraformational slump folds are confined stratigraphically and overlain by normally dipping beds, picked out by the flint bands. In the highest beds exposed in the north-east corner of the pit are several marl seams containing abundant inoceramid shell debris (Figure 3.78).

Biostratigraphy

Fossils collected from this pit have provided conflicting evidence for the age of the chalk at different levels. In the lowest exposures, in the southern part of the pit, a large form of the echinoid *Echinocorys scutata cincta* Griffith and Brydone was collected (Mortimore, 1986a,b). This usually indicates the higher *Offaster pilula* Zone but there is no other supporting evidence for this Zone. It is possible that the *E. s. cincta* represents the upper horizon of this fossil in Gaster's (1924) horizon of small forms (i.e. in beds equivalent to Castle Hill Flints 4 to 11 at Seaford and Newhaven), but the specimen was larger than the forms normally associated with this level. The zonal index belemnite *Gonioteuthis quadrata* (Blainville) has been collected consistently in the Lower Downend Beds or A Beds. Aragonitic and calcitic fossils from the Downend Main Hardground include the ammonites *Scaphites hippocrepis* (DeKay), *Glyptoxoceras* sp., and *Baculites* (Gale, 1980). Belemnites, brachiopods, cephalopod jaws, elasmobranch teeth, teleost bone fragments and mosasaur teeth and bones have also been collected from this horizon. The belemnite genera *Gonioteuthis* and *Belemnitella* are found together in beds above the Downend Main Hardground (Bed A12–13). This belemnite Overlap Zone (Figure 2.27, Chapter 2) is widely recognized in Europe (Schmid, 1953, 1959) but it is only at Downend Chalk Pit that the zone has been studied in detail in England. Brydone's (1912) record of *G. quadrata*, based on a specimen of *G. quadrata gracilis* (Stolley), is the stratigraphically highest yet known in England (see discussion below).

Forms of *Echinocorys* provide index horizons in the Campanian Stage, and Downend has provided a unique collection from various levels. These fossils are still being researched and the different shapes have been given informal names and used for correlation across the Anglo-Paris Basin (Mortimore, 1983, 1986a,b; Mortimore and Pomerol, 1987, 1991a,b). In particular, a tall domed, round-based form is associated with the Downend Main Hardground. Very thick-shelled, globose forms of *E. turrita* are present in the Upper Downend Beds (B Beds above B4) and *E. subconicula* is present in the higher part of the Upper Downend Beds (Figure 3.78).

Beds with fossils typical of the *Belemnitella mucronata* Zone are present in the higher parts of the pit. These fossils include *Belemnitella* (without *Gonioteuthis*), *Echinocorys subconicula* Brydone and abundant inoceramid bivalves including *Cataceramus dariensis* (Dobrov and Pavlova), the last concentrated in marl seams.

Interpretation

Downend Chalk Pit is located on the Portsdown Pericline (Figure 3.79), which is one of a series of en-echelon periclines in this part of the Southern Province and the Paris Basin (Mortimore and Pomerol, 1991a, 1997). Although White (1913) considered that the unusual dips in the Chalk were not related to the tectonic folding, his only alternative explanation was to suggest that some form of cross-bedding related to currents was the cause. Gale (1980) invoked local (salt?) diapirism as a cause of folding, but there is no evidence of subsurface salt. Mortimore (1979, 1983; 1986a,b) and Mortimore and Pomerol (1987, 1991a, 1997) considered that the unusual dips were caused by intraformational slump folding and sliding, which was in turn caused by syntectonic, fault-controlled growth of the Portsdown Pericline. This interpretation was supported by seismic evidence from the Solent that illustrated similar slumping in the Chalk (Mortimore and Pomerol, 1997, fig. 6).

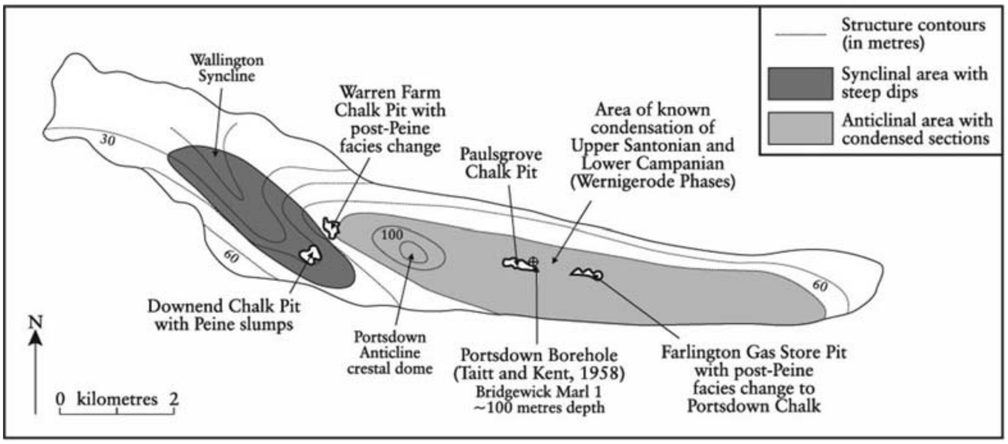


Figure 3.79: Structure contours on the Chalk of Portsdown, showing the shape of the Portsdown Anticline and Wallington Syncline. Peine phase tecto-sedimentary structures are present at Downend Chalk Pit and Warren Farm Chalk Pit, close to the crest and western flank of the structure. (From Mortimore and Pomerol, 1997.)

The Downend slumps are comparable in style and broadly similar in timing to the classic intra-formational Bärsteine slumps of Beckum in the Münsterland Cretaceous Basin of Germany (Voigt and Häntzschel, 1964; Mortimore *et al*., 1998). They are also approximately contemporaneous with the intraformational conglomerates developed adjacent to salt diapirs north of Hannover, in northern Germany (Riedel, 1937). Within the UK, the Downend Main Hardground correlates with the quasi-hardground in the Trunch Borehole of Norfolk (Arthurton *et al*., 1994; Wood *et al*., 1994) and, in France, with the Précy Hardground of the Bray and the distinctive 'key marker' of seismic sections in the Brie (Mortimore and Pomerol, 1997). All of these events, the hardground formation and the growth of slumps and slides, are now interpreted as a response to a major, late Early Campanian tectonic event (the Peine phase of Riedel, 1940, 1942; Mortimore and Pomerol, 1997; Mortimore *et al*., 1998). The two folding phases described by Gale (1980) probably represent the polyphase nature of the Peine Tectonic Event.

None of the present descriptions and explanations fully deals with the anomalously dipping flint-bearing chalk in the now completely buried face to the north of the former entrance (Figure 3.75). These former northern exposures showed steeply dipping flint bands (dipping west and north-west) in white chalks, apparently stratigraphically above the Lower Downend Beds with slumps. This situation is more akin to that in the Warren Farm Chalk Pit, where flint bands in the horizons equivalent to the Upper Downend Beds (all of the B Beds) also show anomalous dips. If these observations are correct, it suggests that slumping may have continued into the Upper Downend Beds and may have involved much larger-scale sliding than has been considered to date. Further thought also needs to be given to the relationship of the Downend structures with those exposed in Paulsgrove Chalk Pit. It is probable that at least the whole western end of Portsdown was involved in complex sedimentary events. These include condensation and synsedimentary faulting in the Newhaven Chalk as well as later Early Campanian events at Downend Chalk Pit and Warren Farm Chalk Pit in the Culver Chalk.

Local network of field sections on Portsdown

Downend Chalk Pit is one of many pits in the Campanian strata on Portsdown. These include sections in the adjacent but now backfilled Warren Farm Chalk Pit (Figures 3.80 and 3.81), and other main sections on Portsdown at Paulsgrove and Farlington (Figures 3.82 and 3.83). Each of these pits, in combination with the exposures at **Whitecliff** and Scratchell's Bay on the east and west sides of the Isle of Wight respectively, provides vital stratigraphical evidence for constructing an onshore Campanian stratigraphy in England and for correlations in Europe.

Within this local network of field sections the lithostratigraphy at Downend Chalk Pit is conspicuously anomalous, reflecting its unusual tecto-sedimentary history. The Warren Farm Chalk Pit was opened briefly during the 1980s for the extraction of chalk for construction of Port Solent Marina, and then backfilled. It exposed the Upper Downend Beds and, possibly, the basal Portsdown Chalk marl seams associated with abundant *Cataceramus dariensis* at the topmost entrance to the pit. The succession passed down through a spectacular band of paramoudra flints (Figure 3.81), which have been correlated with those at Précy-sur-Oise, France (Mortimore and Pomerol, 1991b). Farther below there are beds with marl seams that are correlated tenuously with the Lower Downend Marl (Figure 3.83), as similar forms of *Echinocorys* are present. There is evidence in this pit for disruption of bedding and synsedimentary faulting, again probably related to the Peine phase tectonic pulses on Portsdown (Mortimore and Pomerol, 1991a, 1997).

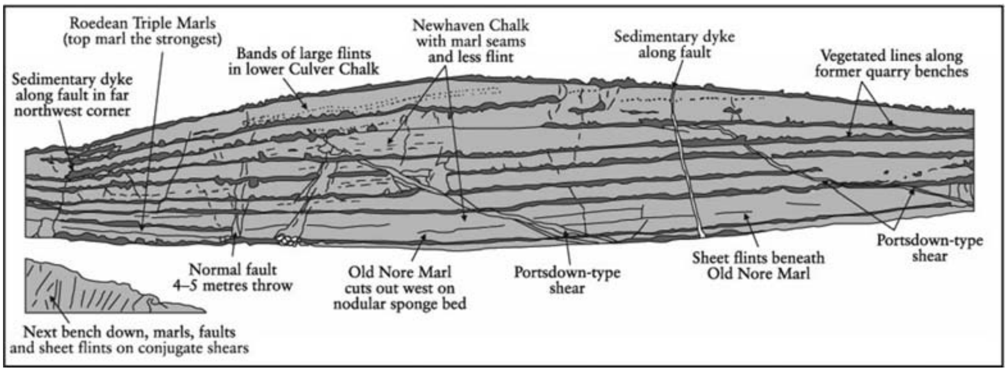
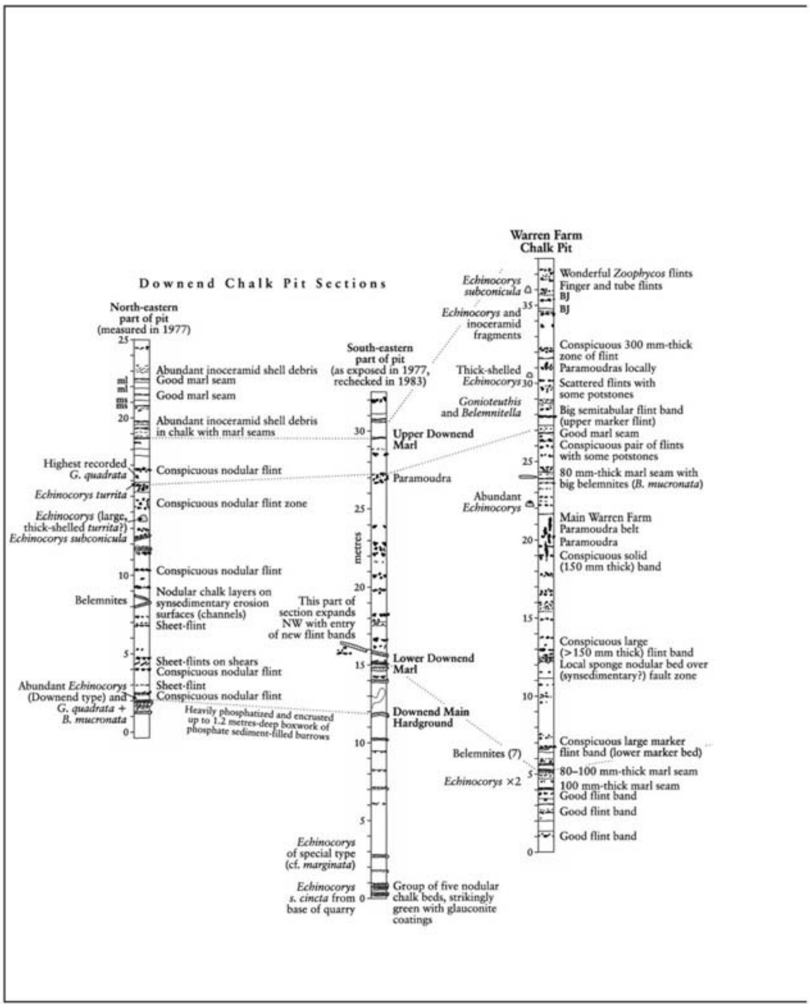


Figure 3.82: Paulsgrove Chalk Pit, Portsdown, Portsmouth, Hampshire.



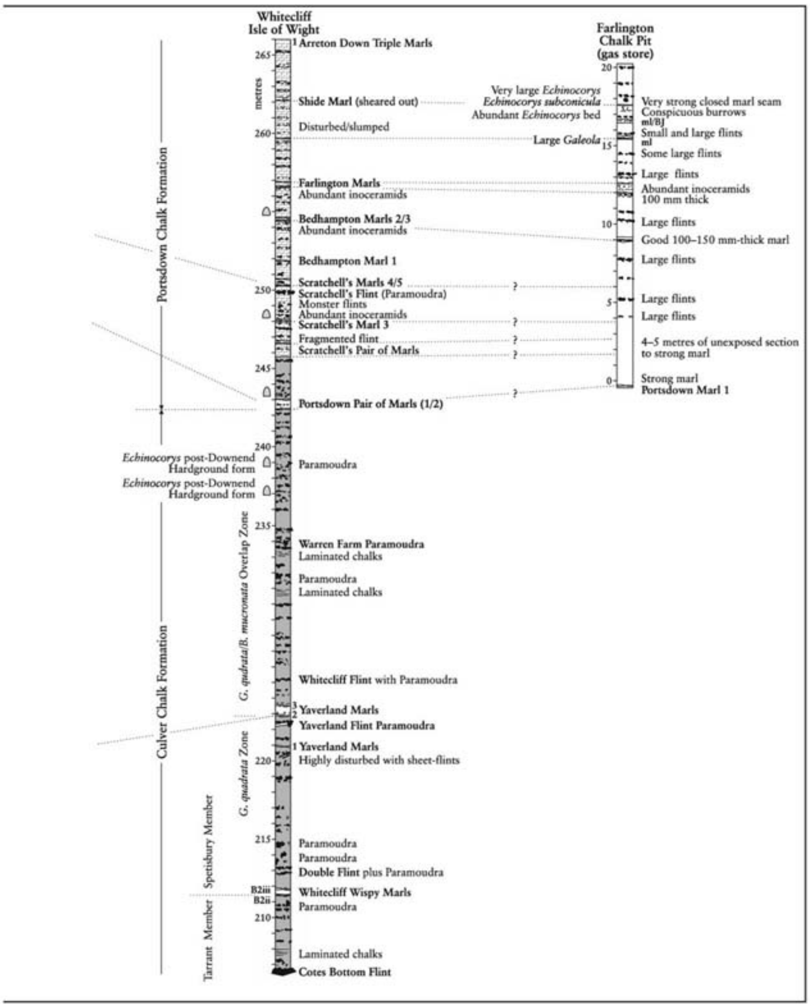


Figure 3.83: A possible correlation between Downend Chalk Pit, Warren Farm Chalk Pit and Farlington Chalk Pit (Gas Store Pit), Portsdown, and Whitecliff, Isle of Wight. B2ii and B2iii refer to the benthic foraminiferal zonal/subzonal scheme of Swiecicki (1980). (BJ = bedding joint; ms = marl seam; ml = marly laminae.)

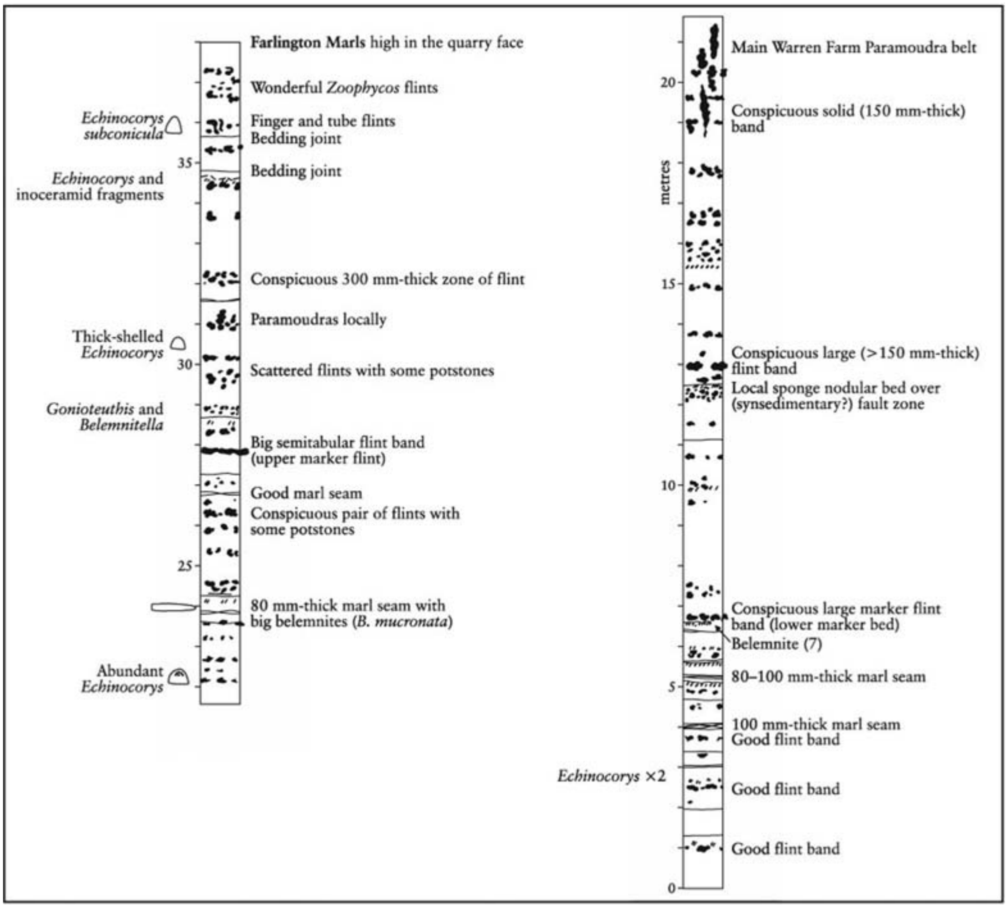


Figure 3.81: The Campanian Chalk succession at Warren Farm Chalk Pit, Portsdown. A vital link with Downend Chalk Pit.

Paulsgrove Chalk Pit is the massive white scar on the south side of Portsdown. It exposes beds through the Newhaven Chalk Formation, from just above the *Marsupites* Zone, to beds in the lower part of the Culver Chalk Formation. The section details were first published by Mortimore (1986a,b), and indicated the thinning of the Newhaven Chalk onto the Portsdown Pericline. Marl seams, from the Rottingdean Pair in the Old Nore Beds, to the Castle Hill Marls, at the boundary with the overlying Culver Chalk, were identified. Out of reach in the high cliff face were the conspicuous Castle Hill Flints. The presence of sedimentary (chalk) dykes (Figure 3.82) here, as well as a special form of shear plane seen only on Portsdown, suggests there is a sedimento-tectonic link between features seen in Paulsgrove Chalk Pit and those at Downend Chalk Pit and Warren Farm Chalk Pit. Recently (1998), the pit has been opened as a recreational area and a ramp of chalk built down the face. This has provided access to the entire cliff, allowing a measured section to be made. This recent landscaping has, however, covered all of the lowest exposures including most of the Old Nore Beds as well as the best of the sedimentary dykes, which were in the far north-west corner.

Farlington Gas Store Pit (Brydone's (1912) Hampshire Pit 1145, his Farlington Redoubt; SU 686 064), is the stratotype locality for the Portsdown Marl, marking the base of the Portsdown Chalk Formation (Mortimore, 1983, 1986a). The group of marl seams and the associated abundant shell fragments of *Cataceramus dariensis,* in the lower part of the formation, are exposed in the northern face of the pit (Figure 3.83). *Belemnitella* is abundant above the Farlington Marls and *Echinocorys subconicula* is also common. It is probable that Griffith and Brydone (1911) and White (1913) took these marls as the base of their *Belemnitella mucronata* Zone. Large, globose, thick-shelled echinoids (*Echinocorys turrita*) and small forms related to *E. s.* ‘pre-*conica* ' occur in the currently grassed-over lowest beds. This distribution of inoceramid bivalves, *Echinocorys* and the belemnites suggests that the lowest, poorly exposed, beds equate with the Upper Downend Beds, and the marls with those at the top of Downend Chalk Pit and Warren Farm Chalk Pit (N.B. the basal boundary marker, the Portsdown Marl, was not exposed at the time of writing).

The Downend Main Hardground contains a unique shallow-water assemblage (mixed, transported and *in situ*) that is not represented elsewhere in the UK. An analogous fauna, of earlier Campanian age, is found in phosphatic chalks (Lavant Stone), north of Chichester, Sussex (Bone and Bone, 2000). Gale (1980) provided details of the Downend Main Hardground surface and the overlying pebble-lag deposit indicating the presence of reworked, phosphatized and encrusted hardground material and steinkerns of fossils. Fossils associated with this surface are diverse and contain both aragonitic and calcitic forms. These are preserved as hollow external and internal moulds in the hardground, as phosphatized steinkerns in the lag above, or as soft, composite moulds in the granular phosphatic chalk above the hardground and in the burrow-fills.

Conclusions

Downend Chalk Pit has provided a unique insight into a part of the Upper Cretaceous stratigraphy, the Lower Campanian Chalk and the base of the Upper Campanian succession, which is difficult to study elsewhere. Coastal cliff sections on the Isle of Wight (**Whitecliff**, Scratchell's Bay) are in steeply dipping hard chalks with short lengths of section, in contrast to the soft chalks and longer lengths of section on Portsdown. Downend Chalk Pit and the adjacent Warren Farm Chalk Pit, are the only localities in the Southern Province where the belemnite ‘Overlap Zone' between *Gonioteuthis* and *Belemnitella* has been worked out in detail. Downend Chalk Pit has additionally provided the highest in-situ record of *Gonioteuthis* in the English Chalk. The stratigraphy exposed at this site fills a vital gap in southern England.

Spectacular synsedimentary slump-folding exposed here is the only known occurrence of such structures in the Lower Campanian strata in England.

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