Chinnor Chalk Pit, Oxfordshire Chiltern Hills

[SU 754 994]

Introduction

The Chinnor Chalk Pit site comprises Chinnor Quarry 3 (Figure 4.19), the most southeastern, and most extensive, of the complex of quarries belonging (until 1999) to Rugby plc. The site exposes a continuous, fossiliferous section at the southern end of the Chiltern Hills through the greater part of the Grey Chalk Subgroup, as well as the lower part of the Holywell Nodular Chalk Formation at the base of the White Chalk Subgroup. Together with other quarry sections in the Chiltern Hills and Barrington Chalk Pit, near Cambridge (see GCR site report, this volume), it provides a key link between the basinal Grey Chalk Subgroup successions of the Southern Province and the condensed Ferriby Chalk Formation successions of the Northern Province. The Grey Chalk Subgroup section is important for its extensive exposure of the Totternhoe Stone, only 30 km southwest of the type locality. Together with Southerham Grey Pit, Folkestone (Folkestone to Kingsdown GCR site), and Beachy Head, Eastbourne, it is one of the most intensively studied Grey Chalk Subgroup sections in the Southern and Transitional provinces in respect of micropalaeontology (foraminifera and ostracods) and stable isotope stratigraphy. The Holywell Nodular Chalk Formation succession is critical, in conjunction with the Pitstone Quarry 2 RIGS site section to the north and that at Shakespeare Cliff, Dover, in establishing the correlation of the Cenomanian–Turonian boundary and basal Turonian successions between the Chiltern Hills and the Southern Province.

Description

Chinnor Chalk Pit (Quarry 3) is a narrow, deep quarry, 950 m long, orientated NE–SW, situated between the Icknield Way and the lower slope of the Chiltern Hills scarp. Access is through a tunnel beneath the Icknield Way. The quarry is *c.* 100 m wide at the south-west end, which is partially flooded, and *c.* 200 m wide at the north-east end, where there are seven faces, each 5–6 m high, separated by benches. The orientation of the quarry is such that the faces expose approximately dip- and strike-sections. The quarry exposes *c.* 35 m of the Grey Chalk Subgroup, which is known from borehole evidence to be *c.* 60 m thick here, and the lowest *c.* 14 m of the Holywell Nodular Chalk Formation at the base of the White Chalk Subgroup.

The following details are largely taken from the account by Sumbler and Woods (1992). The structure is simple, the regional dip, and the overall dip of the succession exposed in the quarry; being only *c.* 0.5°–1° to the south-east; however, the higher beds exhibit opposite dips (up to 8°–11°) to the north-west. Only minimal faulting can be observed in the strike-sections, but the dip-section at the north-east end is extensively affected by closely spaced normal faults, both oblique and sub-parallel to the face. The Plenus Marls Member is affected by normal faults orientated approximately north–south, with displacements of 0.5 m to over 2 m to the east. The only fault that can be traced throughout the north-east faces has a throw of 2 m in the Plenus Marls, reducing to 0.4 m at the level of the Totternhoe Stone.

The Grey Chalk Subgroup section was mentioned by McKerrow and Kennedy (1973). Gale (1990b) provided a log of the lowest beds in the present quarry. Descriptions of the stratigraphy and structure of the entire succession were given by Sumbler and Woods (1992) and Horton *et al.* (1995). A 210 m long tunnel, 5 m in diameter, was bored into the Grey Chalk close to the site in 1974 in order to evaluate methods of investigating ground conditions for the future Channel Tunnel (Varley, 1996). The lithostratigraphy, micropalaeontology and stable isotope stratigraphy of the Cenomanian succession in comparison with that of the standard Folkestone to Kingsdown succession was documented by Moghadam and Paul (2000).

Lithostratigraphy

The succession (Figure 4.2) extends from a level in the West Melbury Marly Chalk Formation of the Grey Chalk Subgroup, 13.5 m beneath the Totternhoe Stone, up to the beginning of the shell-detrital chalks in the Holywell Nodular Chalk Formation, near the base of the White Chalk Subgroup. This figure is a composite of data from the British

Geological Survey log (Sumbler and Woods, 1992, fig. 2), fig. 4 in Moghadam and Paul (2000), a log of the succession beneath the Totternhoe Stone (Gale, 1990) and an unpublished log of the Holywell Nodular Chalk kindly made available by Professor Gale. The Moghadam and Paul log shows an additional 2.5 m beneath the base of the British Geological Survey log, different details of the highest beds beneath the Totternhoe Stone, and a measurement of *c.* 21 m, from the base of the Totternhoe Stone to the base of the Plenus Marls Member, as against 24 m.

Grey Chalk Subgroup

The Lower Chalk of Chinnor was recently divided by the British Geological Survey (Sumbler and Woods, 1992; Horton *et al.,* 1995) into the four traditional lithostratigraphical units applicable in the Chiltern Hills. These were the Chalk Marl (*c.* 11 m exposed), Totternhoe Stone (*c.* 1 m), Grey Chalk (*c.* 23 m) and Plenus Marls (*c.* 1 m). The same scheme was also adopted by Moghadam and Paul (2000). However, as noted by Bristow *et al.* (1997), the Chalk Marl in the Chiltern Hills represents the part of the West Melbury Marly Chalk Formation of the Southern Province that is preserved beneath the sub Totternhoe Stone erosion surface. The Totternhoe Stone itself equates with the basal part of the Zig Zag Chalk Formation, the overlying 'Grey Chalk' constituting the remainder of the formation. In this account the Southern Province lithostratigraphical terminology will be used.

The preserved West Melbury Marly Chalk exhibits the typical succession of well-differentiated marl–limestone precession couplets that is seen in the standard Southern Province sections. Moghadam and Paul (2000, fig. 4) showed that there was a marked upward change, at *c.* 9 m below the Totternhoe Stone, from white chalks to grey chalks, which was not observed by Sumbler and Woods (1992). The thin (*c.* 1 m) brown-coloured, calcarenitic, sandy Totternhoe Stone, developed here in shelf facies, rather than channel facies, stands proud in the faces and can be followed throughout the length of the quarry. The base of the stone, particularly in the south-western part of the quarry, rests with sharp, undulating, and slight erosive contact on the underlying beds. The coarse-grained sediment is piped down in a *Thalassinoides* burrow system for up to 0.5 m below the contact. Phosphatized and glauconitized pebbles, including internal moulds of ammonites, are concentrated at the base, and small phosphatic intraclasts and fish debris are found throughout. The main mass of the stone contains the trace fossil *Teichichnus.* The top of the stone is gradational and is marked by the upper limit of phosphatic intraclasts. An interesting and hitherto unpublished record from here is a find by Dr M. Oates (BG group) of a pebble of arkose, 80 x 40 x 30 mm.

The overlying beds of the Zig Zag Chalk Formation cannot be readily examined in the steep faces. The sediments of the lowest 2 m above the Totternhoe Stone are silty and distinctly pale brown in colour, with scattered pyrite nodules. The greater part of the overlying succession comprises poorly differentiated and relatively inconspicuous alternations of thin, slightly darker coloured, bioturbated marls and thicker units of off-white chalk. A massive bed, 2 m thick, of slightly silty chalk with scattered pyrite nodules (Sumbler and Woods' Bed El), with a 0.50 m thick marl (F4) at its base, *c.* 7 m above the Totternhoe Stone, and overlain by a closely spaced marl-pair (E2, E4), is inferred to equate with Jukes-Browne Bed 7 of the basinal successions. In the highest 4 m beneath the Plenus Marls the differentiation into marls and chalks becomes more noticeable; although Moghadam and Paul (2000) found no evidence for this. Sumbler and Woods (1992) suggested that the wavy basal contact between their beds D2 and D3, *c.* 4 m beneath the Plenus Marls, may represent a scoured surface, or even a regional erosion surface.

White Chalk Subgroup

The relatively dark-coloured Plenus Marls Member forms a conspicuous marker horizon in the higher part of the quarry and emphasizes the effects of the faulting. Compared to its development in sections in the central and northern part of the Chiltern Hills, the member is extremely thin here (up to 1 m, depending on the degree of compaction), and the standard eight beds (Jefferies, 1963), particularly beds 4–8 inclusive, cannot always be readily identified. Burrows extend down from the undulating sub-Plenus erosion surface for up to 0.5 m, but are concentrated in the top 0.1 m.

There is an excellent exposure of the basal beds of the Holywell Nodular Chalk Formation above the Plenus Marls section, and inaccessible exposures of even higher beds in the same formation. The highest beds appear to belong to the interval, two-thirds of the way up this formation, that is composed of the most shell-detrital-rich sediments. The section log given here (Figure 4.2) differs somewhat in detail from the published British Geological Survey log (Sumbler and Woods, 1992, fig. 2; Horton *et al.,* 1995, fig. 23).

Biostratigraphy

The lowest beds exposed, which are best seen at the south-west end of the quarry, lie in the lower part of the Lower Cenomanian *Mantelliceras dixoni* Zone. Even lower beds, formerly exposed in deep trenches at the base of Quarry 2, yielded an ammonite assemblage dominated by *Mantelliceras saxbii* (Sharpe) with subordinate *Mariella lewesiensis* (Spath) and *Schloenbachia* sp.. This important material, which is housed in the University Museum, Oxford (McKerrow and Kennedy, 1973), must have its provenance in the *Mantelliceras saxbii* event bed in the higher part of the underlying *Mantelliceras saxbii* Subzone of the *Mantelliceras mantelli* Zone. Sumbler and Woods (1992) inferred that this bed equated with a bed, *c.* 15 m above the base of the Grey Chalk Subgroup, that had been mapped in the surrounding area.

In the lowest part of the section, a cemented limestone (Sumbler and Woods Bed H15) containing common three-dimensional *Inoceramus* ex gr. *virgatus* Schlüter with the valves associated, represents the Dixoni Limestone marker horizon of sections in the northern Chiltern Hills (Shephard-Thorn *et al.,* 1994). This bed correlates with a pair of closely spaced spongiferous limestones in the Folkestone to Kingsdown section (marker M6 of Gale, 1989), which likewise, marks the top of an interval in which the inoceramid assemblage comprising *I.* ex gr. *virgatus* with subordinate *Inoceramus crippsi* Mantell, is increasingly dominated upwards by *I.* ex gr. *virgatus.* The Dixoni Limestone at Chinnor is very fossiliferous, having yielded, in addition to the inoceramid bivalves, serpulids, the long-ranging bivalves *Plagiostoma globosum* J. de C. Sowerby and *Plicatula inflata* J. de C. Sowerby, and the stratigraphically relatively restricted small brachiopod *Monticlarella? rectifrons* (Pictet and Campiche). The only ammonite recorded so far is a large unidentified *Acompsoceras* sp. (Sumbler and Woods, 1992).

A 0.3 m bed of spongiferous limestone, some 3 m beneath the base of the Totternhoe Stone, yielded three specimens of the heteromorph ammonite *Turrilites scheuchzerianus* Bosc (Gale, 1990b), enabling correlation with the *scheuchzerianus* event bed at Southerham Grey Pit (see GCR site report, this volume). This marker horizon is not readily identifiable in the published section, but may, contrary to the interpretation by Sumbler and Woods (1992), equate with the lower part of Bed H21, rather than with the slightly silty Bed H23. As a result of sub Totternhoe Stone erosion the basal Middle Cenomanian ammonite Zone of *Cunningtoniceras inerme* appears to be completely missing (see below).

The Totternhoe Stone is very fossiliferous (collecting is best from fallen blocks) and is well known to local collectors for its vertebrate remains, including (M. Oates, pers. comm., 1997) bones of flying reptiles (pterosaurs) and large vertebrae of lamnid sharks. A turtle humerus was collected from this bed in the Pitstone Quarry. The Totternhoe Stone at Chinnor also yields abundant teeth of sharks, including *Cretolamna appendiculata* (Agassiz) and species of *Notidanus* and *Squalicorax,* with smaller numbers of ray teeth (*Ptychodus).* The Totternhoe Stone is inferred to represent, in condensed form, the *Turrilites costatus* Subzone of the Middle Cenomanian *Acanthoceras rhotomagense* Zone. The base of the stone here contains well-preserved three-dimensional phosphatized internal moulds (steinkerns) of ammonites, including *Acanthoceras rhotomagense* (Brongniart), *Cunningtoniceras* sp., *Schloenbachia coupei* (Brongniart), *Sciponoceras baculoides* (Mantell) and *Turrilites costatus* Lamarck (McKerrow and Kennedy, 1973). The Totternhoe Stone also yields poorly preserved unphosphatized composite moulds of large ammonites such as *Acanthoceras* and *Parapuzosia* (*Austiniceras*), which represent indigenous faunal elements. As in other localities in the Chiltern Hills, the small, coarsely ribbed rhynchonellid brachiopod *Orbirhynchia mantelliana (*J. de C. Sowerby) occurs in profusion throughout the Totternhoe Stone, and a rich indigenous fauna of bivalves (notably *Plagiostoma globosum, Plicatula inflata,* various oysters and the thin-shelled pectinacean *Entolium orbiculare (*J. Sowerby)) and terebratulid brachiopods is found concentrated at the base. The geographically widely distributed, but stratigraphically restricted belemnite, *Praeactinocamax* (formerly *Actinocamax*) *primus* (Arkhangelsky) also occurs.

The beds immediately overlying the Totternhoe Stone contain the terebratulid brachiopod *Concinnithyris subundata,* (J. Sowerby), which elsewhere characterizes the succeeding *Turrilites acutus* Subzone. The higher beds are relatively poorly fossiliferous. The marls immediately overlying the inferred equivalent of Jukes-Browne Bed 7 contain small oysters (*Amphidonte* sp.), some with atttachment areas moulding the inoceramid bivalve *Inoceramus pictus* J. de C. Sowerby. However, the thin marl with sparse small pycnodonteine oysters that is found elsewhere in the Chiltern Hills (e.g. Totternhoe Quarry) at the base of this bed has not so far been identified. This oyster horizon may be represented by part of the interval of marly chalk with marls comprising beds F3 to F5 (of Sumbler and Woods, 1992), or it may be situated in the immediately overlying obscured part of the section at the foot of the next face. *Amphidonte* sp. together with common specimens of the thin-tested echinoid *Sternotaxis gregoryi* (Lambert), are also found some metres higher, in Bed D1.

Although well exposed, the very condensed Plenus Marls Member has yielded only a limited fauna. As usual, small to medium-sized oysters (*Pycnodonte*) and the large rhynchonellid brachiopod *Orbirhynchia multicostata* Pettitt are common in the basal marly Jefferies' Bed 1, and the eponymous belemnite, *Praeactinocamax* (formerly *Actinocamax) plenus* (Blainville) can be collected from the silty Jefferies' Bed 4.

The extremely indurated (topmost Cenomanian) limestones overlying the Plenus Marls Member (Sussex Melbourn Rock of Mortimore, 1986a; the Ballard Cliff Member of Gale, 1996) are readily accessible and, as elsewhere, contain the straight heteromorph ammonite *Sciponoceras bohemicum anterius* Wright and Kennedy and spines of the regular echinoid *Hirudocidaris hirudo* (Sorignet). Rhynchonellid brachiopods are characteristically absent from this interval everywhere. The reappearance of *Orbirhynchia* in a silty bed (Sumbler and Woods Bed C20), 1.8 m above the Plenus Marls, is an important Lower Turonian bio-event that can be used for correlation with sections in the Southern Province (see below). The highest beds in the quarry are shell-detrital chalks rich in fragments and complete valves of the inoceramid bivalve *Mytiloides.*

Interpretation

The preserved thickness of the West Melbury Marly Chalk Formation below the Totternhoe Stone is inferred from boreholes to be between 36 and 40 m. This thickness compares with a similarly inferred thickness of *c.* 50 m at Pitstone Quarry, 23 km to the north-east, and, in the northern part of the Chiltern Hills, the 54 m proved below the Totternhoe Stone by the British Geological Survey Sundon Borehole [TL 0405 2724] in the base of Sundon Quarry (Shephard-Thorn *et al.,* 1994). To place this expansion in context, the thickness of the entire formation in the Folkestone to Kingsdown cliff section is only of the order of 34 m (Figure 4.3). The greatest expansion in the West Melbury Marly Chalk Formation in the Chiltern Hills is actually found in the succession below the Dixoni Limestone and, particularly, in the succession below the Doolittle Limestone, including the basal beds with *Aucellina.*

The occurrence at Chinnor in Quarry 2, at a lower stratigraphical level than the lowest beds exposed in Quarry 3, of the event bed with *Mantelliceras saxbii* is noteworthy. This bed must fall in the interval between the Dixoni Limestone and the Doolittle Limestone.

Chinnor Chalk Pit is one of only three localities in England where this bed, situated in the higher part of the *Mantelliceras saxbii* Subzone of the *Mantelliceras mantelli* Zone has been recognized, the other localities being Southerham Grey Pit, Lewes, and Compton Bay, Isle of Wight. Elsewhere, this bed has either been removed by the erosive event that preceded the deposition of the overlying *Mantelliceras dixoni* Zone sediments, or it is not sufficiently cemented to preserve ammonites.

The distinctive event bundle, within the *Mantelliceras dixoni* Zone, comprising the strongly cemented, sponge-rich Dixoni Limestone, an overlying bed of many chalk with small brachiopods (locally including *Orbirhynchia mantelliana),* and a conspicuous dark marl, is readily recognizable near the base of the section. The brachiopod bed equates with the lowest of the three horizons with *Orbirhynchia mantelliana* in the Grey Chalk Subgroup of the Southern Province, and with the lower of the two horizons in the condensed Ferriby Chalk Formation of the Northern Province. However, in contrast to the other Chiltern Hills sections, *Orbirhynchia mantelliana* has not so far been found here in this bed. The dark marl, seen particularly well in the Folkestone section (cf. Gale, 1989, fig. 3), is an excellent marker horizon throughout the Chiltern Hills. The composite event bundle enables Chinnor Chalk Pit to be directly correlated with standard Southern Province successions (e.g. Folkestone to Kingsdown) and with sections in the northern Chiltern Hills, for example Sundon Quarry [TL 041 267] and Barton-le-Clay Quarry [TL 079 296] (Shephard-Thorn *et al.,* 1994).

Two developments of the Totternhoe Stone can be distinguished in the region around Chinnor Chalk Pit. The first is a thin (less than 1 m thick), highly fossiliferous bed, with numerous *Orbirhynchia mantelliana* and small phosphatic intraclasts scattered throughout (the 'shelf facies'). The second is a much thicker, relatively poorly fossiliferous, 'channel facies', characterized by the trace fossil *Teichichnus* (Shephard-Thorn *et al.,* 1994; Hopson *et al.*, 1996). It is the 'shelf facies' that is found at Chinnor Chalk Pit. The channel facies is up to 4.7 m thick at the type locality in the Totternhoe Stone Pit, within the Totternhoe Quarry [SP 988 222], and it is separated from the shelf facies elsewhere in the quarry by a distance of 200 m or less (Shephard-Thorn *et al.,* 1994, fig. 25). North of Hitchin, at Arlesey (Green Lagoon Pit) [TL 1978 3486], the channel facies comprises a complex succession, *c.* 6 m thick, of calcarenites overlain by calcisiltites, whereas the shelf facies in the adjacent Blue Lagoon Pit [TL 1972 3444], only 300 m away, consists of only *c.* 1 m of calcarenites (Hopson *et al.,* 1996, fig. 10). The channel facies always involves a greater extent of pre Totternhoe Stone erosion than the shelf facies: in the Totternhoe Stone Pit, erosion has cut down into the higher part of the Aucellina Beds (Figure 4.3).

The Totternhoe Stone section at Chinnor Chalk Pit can be linked in a network to several other sections in the Chiltern Hills. These include the type locality Totternhoe Lime Quarry [SP 980 222], where both the shelf and channel facies are developed (Shephard-Thorn *et al.,* 1994, fig. 25), Houghton Regis Quarry ca. [TL 005 236], Barton-le-Clay Quarry (Shephard-Thorn *et al.,* 1994), the two adjacent sections at Arlesey, Green Lagoon and Blue Lagoon which exhibit the channel and shelf facies respectively (Hopson *et al.,* 1996, fig. 10), and Barrington Chalk Pit. At Chinnor Chalk Pit, the basal contact of the Totternhoe Stone is situated *c.* 5 m above the Dixoni Limestone, and only c. 3 m above the event bed with *Turrilites scheuchzerianus,* which is found elsewhere (e.g. Southerham Grey Pit) in the higher part of the *Mantelliceras dixoni* Zone. This means that the basal beds of the Middle Cenomanian (*Cunningtoniceras inerme* Zone), and the highest part of the Lower Cenomanian *dixoni* Zone (an interval of *c.* 6–7 m in the Southern Province sections), are missing at Chinnor Chalk Pit. Farther to the north (Figure 4.3), pre Totternhoe Stone erosion has cut down much deeper, for example in the Totternhoe Quarry, where the base of the shelf facies of the Totternhoe Stone rests on the Dixoni Limestone itself, while in the nearby Stone Pit the channel facies rests on a level near the base of the Grey Chalk Subgroup. The sub-Totternhoe stratigraphy at Houghton Regis is somewhat dificult to interpret, but at Barton-le-Clay Quarry, the basal contact is only 3.5 m above the Dixoni Limestone.

Moghadam and Paul (2000, fig. 4) show a $\delta^{13}C$ curve that does not exhibit the double-peaked positive excursion that is found above and below the Cast Bed at Folkestone and correlative localities (Paul *et al.,* 1994). They use this absence to suggest that the Totternhoe Stone has eroded down from above the Cast Bed. They also identified (their fig. 6) a sudden increase in the proportion of planktonic foraminifera in the assemblage at the higher of two conspicuous marl seams *c.* 3 m above the base of the Totternhoe Stone and correlated this with the so-called 'P/B break', identified by Carter and Hart (1977a) in the Southern Province. On this basis, the boundary between the *Turrilites costatus* and *T. acutus* subzones of the *Acanthoceras rhotomagense* Zone must lie at, or slightly higher than, this level.

Sumbler and Woods' Bed E1, which has a slightly gritty texture, corresponds to the Chiltern Hills equivalent of Jukes-Browne Bed 7 of the Southern Province or, alternatively, to a very poorly lithified and ill-defined development of the Nettleton Stone of the Northern Province. It is underlain by three marls from which Moghadam and Paul (2000) recorded the oyster *Pycnodonte,* confirming the position of the *Pycnodonte* event of northern European event stratigraphy, and it is overlain by a pair of marls containing the oyster *Amphidonte.* This latter oyster occurrence appears to correlate with the lower of two *Amphidonte* events (Ernst *et al.,* 1983) recognized in Westphalia, northern Germany (Kaplan *et al.,* 1998) at this level. The higher *Amphidonte* occurrence, associated with the inoceramid bivalve *Inoceramus pictus* and the thin-tested echinoid *Sternotaxis gregoryi,* in Bed D1, probably correlates with the higher of the two German *Amphidonte* events. The glauconitized/phosphatized pebble bed in a coarse-grained chalk matrix (the 'Buckinghamshire Rag' of the earlier literature), that is locally developed at this horizon to the north-east in Pitstone Quarry 2 and, associated with abundant thick-shelled terebratulid brachiopods (*Ornatothyris sulcifera* (Morris)), in the Totternhoe Lime Quarry (Shephard-Thorn *et al.,* 1994) and the former Grove Mill Quarry Hitchin (Hopson *et al.,* 1996), is not found at Chinnor.

In marked contrast to the relative expansion in the Chiltern Hills of the preserved West Melbury Marly Chalk Formation, the Zig Zag Chalk Formation, particularly the interval from the base of the Totternhoe Stone to the base of the equivalent of Jukes-Browne Bed 7, is conspicuously thinner than in Southern Province successions. This is largely due to the strong condensation represented by the Tottternhoe Stone itself. The interval from the top of the Jukes-Browne Bed 7 equivalent to the sub-Plenus erosion surface (i.e. the White Bed of the North Downs), on the other hand, retains a more or less constant thickness of the order of 15–16 m from the North Downs to Chinnor Chalk Pit. At the former Butler's Cross Quarry [SP 843 070], 11 km to the north-east of Chinnor, the interval from the base of the Plenus Marls Member to the inferred correlative of the Buckinghamshire Rag, is only some 5 m in extent (Jefferies, 1963). This could be interpreted as the result of pre-Plenus Marls erosion. However, at the Pitstone Quarry 2 RIGS site, where the Buckinghamshire Rag is locally developed, the sub-Plenus erosion surface is situated less than 1 m above a hardground.

The 13 m section in the Holywell Nodular Chalk Formation above the Plenus Marls Member is potentially of importance in establishing the correlation with the relatively condensed succession in the North Downs and the more expanded succession at Beachy Head, Eastbourne, using the marker horizons documented by Gale (1996). Compared with Dover, the basal beds (Gale's Ballard Cliff Member) are only 0.7 m thick as against 1 m. The lowest two couplets belong to the highest part of the *Metoicoceras geslinianum* Zone, and the remainder of the unit can be inferred to belong to the overlying terminal Cenomanian *Neocardioceras juddii* Zone (Figure 4.2). The top of this unit marks the approximate position of the Cenomanian–Turonian boundary, and the inferred base of the *Watinoceras devonense* Zone. The calcarenitic bed that is used in the Chiltern Hills and the Hitchin area as a correlative of the base of the Holywell Marl 2–Holywell Marl 3 interval (Wood, 1993; Hopson *et al.,* 1996) can be identified 1.8 m above the Plenus Marls Member. This bed marks the first occurrence of *Orbirhynchia* in the Holywell Nodular Chalk above the Plenus Marls Member and, by extrapolation from Dover, the base of the *Fagesia catinus* ammonite Zone. The interval up to 5 m above the Plenus Marls is rather inaccessible and incompletely exposed. These beds were assigned to the Melbourn Rock by Horton *et al.* (1995); however, the upper limit chosen by those authors is probably significantly higher than the top of the Melbourn Rock as identified by Hopson *et al.* (1996) at Ashwell Quarry [TL 2687 3945], in the single extant locality of the three original type localities, namely Melbourn, Ashwell, and Hitchin railway cutting quarry.

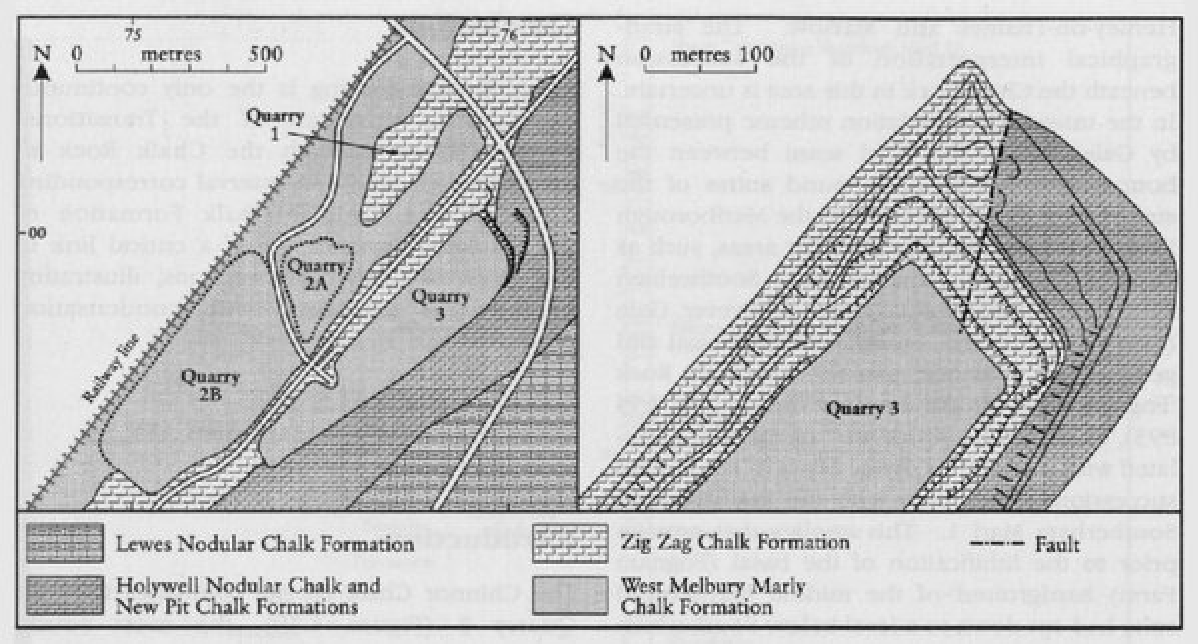
The 0.10 m intraclastic marl, and the 0.05 m flaser marl overlying indurated nodular chalk, at 5 m and 6 m above the Plenus Marls Member respectively, are inferred to correlate with the Gun Gardens Marls in the sense of Gale (1996). The base of the lower of these two marl seams was taken by Horton *et al.* (1995) to mark the top of the Melbourn Rock. The extremely shell-detrital-rich chalks above and below a marl seam 8.3 m above the base are tentatively correlated with the beds associated with the Gun Gardens Marls as originally described by Mortimore (1986a) and by Mortimore and Pomerol (1996). The *Filograna avita* horizon, which occurs towards the top of this interval (Gale, 1996), and is approximately coincident with the most shell-detrital chalk in the Holywell Nodular Chalk Formation, has not so far been identified at Chinnor, but its inferred position is shown on (Figure 4.2). It is known to be present near the top of the Pitstone Quarry 2 RIGS site section, 24 km to the north. The latter locality is the most northerly section where this important bio-event is seen in its normal development.

The highest beds at Chinnor Chalk Pit consist of some 2 m of shell-detrital chalks underlain by a marl seam. It is possible that this latter marl seam is the equivalent of the Aston Marl (see p. 305), which is seen farther to the north in the Ivinghoe-Aston Pit [SP 960 176] and at the top of the Totternhoe Quarry 2A. This marl seam marks the lowest level at which flint is developed in the Holywell Nodular Chalk in the central and northern Chiltern Hills. If this correlation is correct, it suggests that the top of the preserved Chalk at Chinnor Chalk Pit may be relatively close to the top of the Holywell Nodular Chalk. However, there is no evidence of flint at this level in this part of the Chiltern Hills.

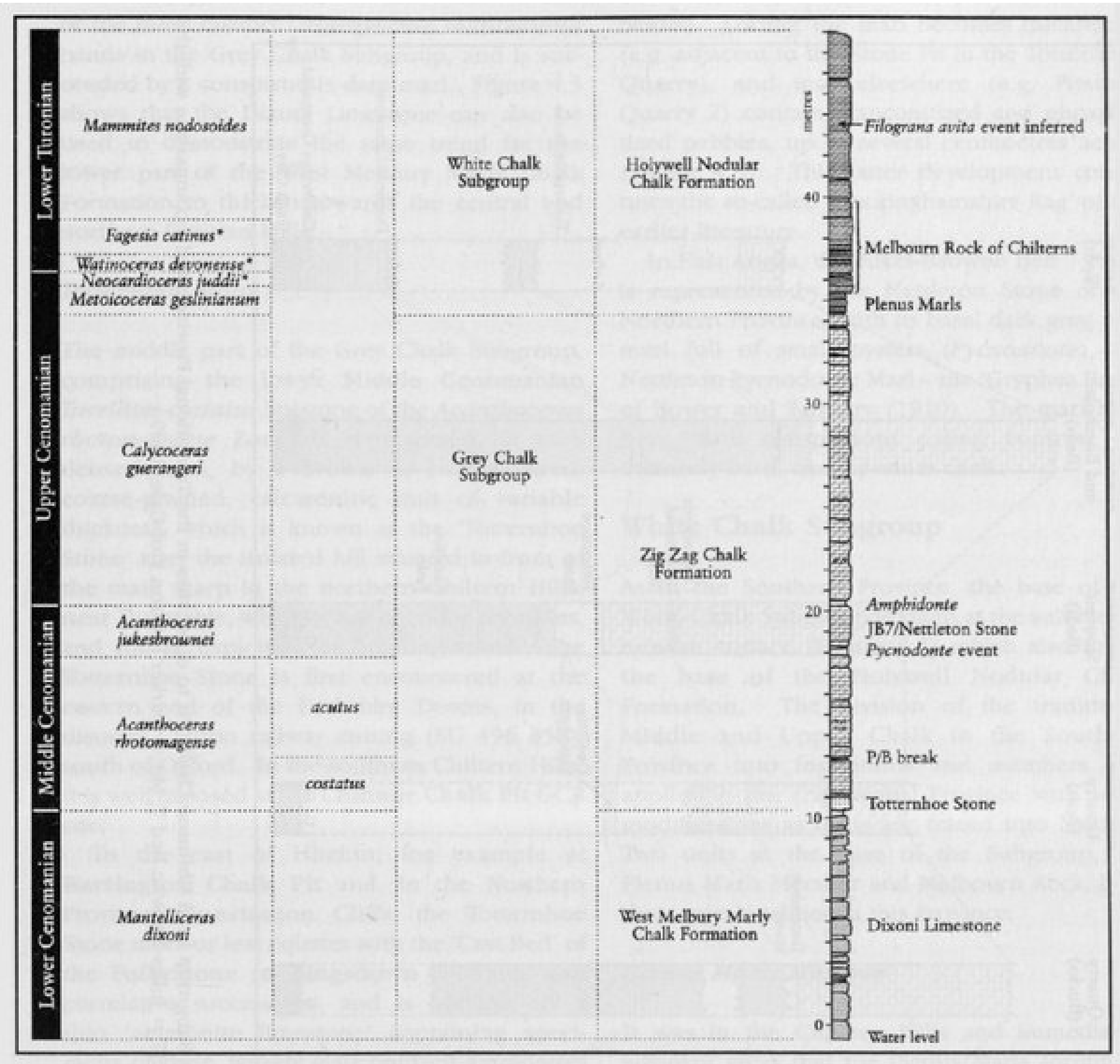
Conclusions

The site exposes one of the most important successions in the Transitional Province, spanning the greater part of the West Melbury Marly Chalk, the Totternhoe Stone (which is particularly fossiliferous here), the Zig Zag Chalk Formation and the Holywell Nodular Chalk Formation. It is one of the most intensively researched Grey Chalk Subgroup sites in the UK in respect of integrated macrofossil and microfossil biostratigraphy, as well as stable isotope stratigraphy, and it can be used to link the Transitional Province to the standard Southern Province successions in the Folkestone to Kingsdown and Southerham Grey Pit GCR sites.

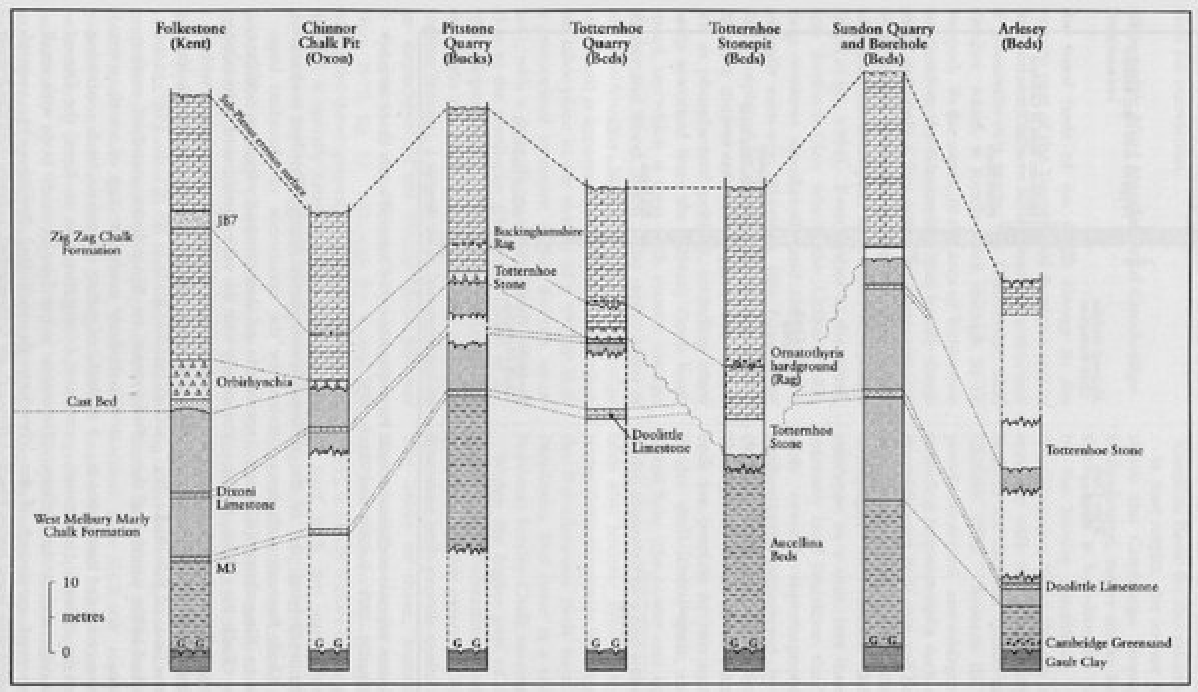
References



(Figure 4.19) The Chinnor quarries, Oxfordshire, exposing the Grey Chalk Subgroup and basal units of the White Chalk Subgroup.



(Figure 4.2) Chalk succession exposed in Chinnor Chalk Pit, Oxfordshire (= inferred zones based on other sections and associated fossils). (After Sumbler and Woods, 1992.)*



(Figure 4.3) Correlation of the Cenomanian Grey Chalk Subgroup from Chinnor Chalk Pit to other sites in the Transitional Province and a comparison with the Folkestone standard section. (G = Glauconitic Marl; JB7 = Jukes-Browne Bed 7; M3 = marker horizon 3 of Gale, 1989.)