WINTERBOURNE CHALK PIT

OS Grid Reference: SU448722

Introduction

Winterbourne Chalk Pit is an old farm quarry, situated 100 m south-west of Lower Farm and west of the track that joins Winterbourne Manor and Lower Farm (Figure 4.7). This is one of the few localities in the UK that exposes a section in the flintless phosphatic chalk lithofacies. As in the case of the **South Lodge Pit** GCR site at Taplow near Maidenhead, this site provides an excellent example of a biostratigraphically well-constrained condensed Upper Santonian–Lower Campanian phosphatic chalk succession that is comparable, in some respects, with the more extensive, and broadly coeval, phosphatic chalk developments exposed in abandoned quarries in northern France. The section is rich in macrofossils, particularly belemnites, which are otherwise rare in basinal equivalents. The site also shows that the development of phosphatic chalk, seen at the top of the nearby **Boxford Chalk Pit** GCR site, continued well into the Campanian Stage. This condensed flintless chalk succession, which includes four hardgrounds, can be correlated with part of the succession of hardgrounds that constitutes the so-called 'flintless belt' of the **Whitecliff** GCR site on the eastern side of the Isle of Wight, and likewise provides evidence of the effects on sedimentation of intra-formational tectonism developed over basement lineaments.

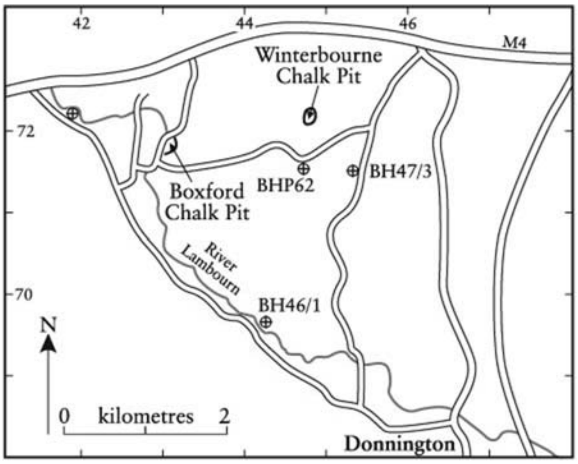

Figure 4.7: Location of Boxford Chalk Pit and Winterbourne Chalk Pit in the River Lambourn valley north of Newbury. (BH=Boreholes with geophysical logs that extend the stratigraphy to the Chalk Rock and below.)

Description

The section at Winterbourne Chalk Pit, originally described at the beginning of the 20th century by White and Treacher (1906), had become seriously degraded and was re-excavated by the Nature Conservancy Council in 1978 to reveal a 6 m section (Figure 4.10), extending over 20 m (Jarvis and Woodroof, 1981). The beds dip at about 3º to the south-west. Jarvis and Woodruff additionally compared the section with sections containing phosphatic chalk at **Boxford Chalk Pit** and **South Lodge Pit**. The site was again re-excavated by English Nature in 1999.

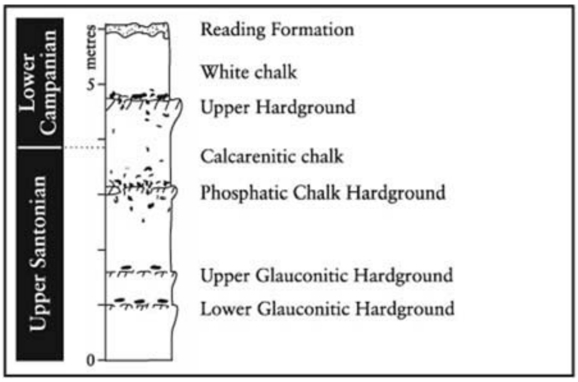

Figure 4.10: Chalk succession exposed at Winterbourne Chalk Pit near Newbury, Berkshire. (After Jarvis and Woodroof 1981, fig. 5.)

Lithostratigraphy

The initial description by White and Treacher (1906) related only to the higher part of the section, the lower beds being then obscured by talus. An excellent description of the re-exposed section, including glauconitized hardgrounds not seen by White and Treacher, was given by Jarvis and Woodroof (1981). The following account and log (Figure 4.10) draws extensively on both of these descriptions.

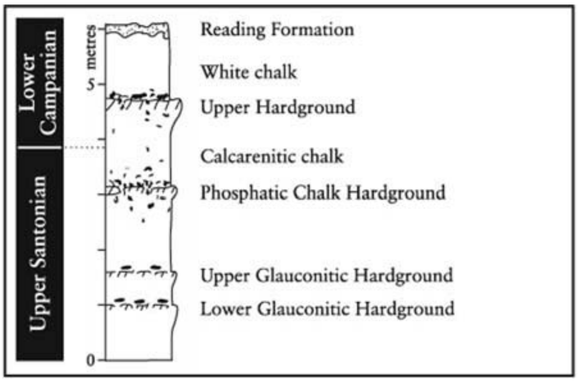

Figure 4.10: Chalk succession exposed at Winterbourne Chalk Pit near Newbury, Berkshire. (After Jarvis and Woodroof 1981, fig. 5.)

The succession includes four hardgrounds named by Jarvis and Woodroof (1981), in ascending order, the poorly lithified Winterbourne Lower Hardground and Upper Glauconitic Hardground, the more strongly lithified Winterbourne Phosphatic Chalk Hardground, and the very strongly lithified Winterbourne Upper Hardground. It must be emphasized that these hardgrounds do not relate in any way to hardgrounds with similar names described by those authors from the nearby **Boxford Chalk Pit** (see GCR site report, this volume), which belong to stratigraphically lower horizons. All of the hardgrounds are weakly glauconitized, the two higher ones being additionally limonite-stained, with the Upper Hardground being also locally phosphatized. The Phosphatic Chalk Hardground contains many limonitized hexactinellid sponges and is penetrated by a *Thalassinoides* burrow system; the hardground surface possesses a marked relief, with bosses up to 0.1 m high encrusted by pycnodonteine oysters. The Upper Hardground incorporates limonitized sponges as well as phosphatized and glauconitized intraclasts up to 0.1 m across; the hardground surface is of lower relief than that of the underlying hardground, and is encrusted by *Atreta* and *Spondylus*, in addition to oysters.

The white chalk at the base of the section contains scattered pelletal phosphate. Each of the lower hardgrounds is overlain by white chalk with scattered pelletal phosphate, similar in lithology to the lowest bed, with a thin basal lag of phosphatized and glauconitized intraclasts. The content of pelletal chalk and intraclasts increases upwards in the interval between the Upper Glauconitic and the Phosphatic Chalk Hardground. At the top of this interval, colour-contrasting grey, calcarenitic, pelletal phosphate-rich chalk is conspicuously piped down from above the hardground in *Thalassinoides* burrows. The chalk above the Phosphatic Chalk Hardground is overall greyish-white, very coarse-grained and rough-textured owing to a high content of fragmented and/or comminuted oyster and inoceramid shell material, and contains numerous phosphatized/glauconitized intraclasts. Pelletal phosphate occurs throughout, but is concentrated in the darker grey basal 0.1 m. Jarvis and Woodroof (1981) noted that the Upper Hardground is overlain by a basal concentration of pelletal phosphate chalk with phosphatized intraclasts, scattered glauconite grains and sporadic well-rounded quartz grains. Phosphatized intraclasts continue for another 0.3 m, above which the chalk becomes fine-grained, completely devoid of pelletal phosphate or phosphatized intraclasts, but contains instead dark specks of iron and manganese oxide.

Biostratigraphy

Calyx plates and arm ossicles of the Upper Santonian zonal index crinoid *Marsupites testudinarius* (Schlotheim) were reported by White and Treacher (1906) to occur throughout the section below the Phosphatic Chalk Hardground (their 'Bed 2'), but to become common in the topmost 0.3–0.6 m, where they noted that 'there are probably about a dozen plates per cubic foot of chalk'. They also recorded specimens of *Marsupites* in the Phosphatic Chalk Hardground itself, and in the overlying phosphatic chalk (their 'Bed 3'), where *Marsupites* plates were noted as being fairly common in the lowest part of the bed, becoming scarce some 0.2 m above the base, and disappearing altogether at about 0.75 m above the base. At the level where *Marsupites* first became scarce, White and Treacher (1906) reported a single specimen of the belemnite *Actinocamax verus* Miller and the appearance of the belemnite genus *Gonioteuthis*; the latter occurs sporadically throughout the remainder of the bed above this level. The reported Riedel Quotient (ratio of alveolar depth to the length of the belemnite) for the *Gonioteuthis* of between 5 and 7 places them within the range of populations of *Gonioteuthis granulata* (Blainville) from the *Marsupites* Zone of northern Germany (cf. Ernst, 1964). The shell-detrital phosphatic chalks also yield the distinctively pyramidate *Marsupites* Zone echinoid *Echinocorys scutata elevata* Griffith and Brydone and, particularly in the higher part of the bed, *Micraster rostratus* (Mantell) and less pyramidate *Echinocorys* morphotypes approaching *E. scutata tectiformis* Griffith and Brydone. The Upper Hardground contains common *Gonioteuthis* and *E. scutata tectiformis*, associated with a rich sponge fauna (of which the determinations cited by White and Treacher need revision), and also marks the first recorded appearance in the section of the small echinoid, *Offaster pilula* (Lamarck).

Resting on, or in, the basal 0.1 m of chalk above the Upper Hardground, *Echinocorys scutata tectiformis* and *Gonioteuthis* with a Riedel Quotient of 4.5 to 6 occur in flood abundance, together with common *Offaster pilula*. The belemnites were reported by White and Treacher (1906) to be even more abundant than in the 'Upper Brown (phosphatic) Chalk' unit of **South Lodge Pit** (see GCR site report, this volume). On the basis of their Riedel Quotients, the belemnites fall within the range of populations of *G. granulataquadrata* (Stolley) or *G. quadrata* (Blainville). The echinoids and belemnites become scarce about 0.3 m above the hardground, and are absent from the highest part of the section, from which White and Treacher (1906) recorded only biostratigraphically non-diagnostic oysters, '*Pecten cretosus*, *Spondylus latus* and *Rhynchonella plicatilis* '.

Interpretation

The macrofaunal evidence supports the interpretation given by Jarvis and Woodroof (1981), who considered that the boundary between the *Marsupites testudinarius* Zone and the overlying *Echinocorys scutata depressula* Subzone of the *Offaster pilula* Zone should be drawn at the disappearance of *Marsupites* within the shell-detrital chalk unit above the Phosphatic Chalk Hardground. The literature evidence that unequivocal *Marsupites* calyx plates, rather than merely crinoid brachials, which could include *Uintacrinus*, range right down to the base of the section, i.e. below the two glauconitic hardgrounds, needs confirmation. It is also possible that the lowest records refer to the lower of the two *Marsupites* calyx plate morphotypes (see p. 68, Chapter 2) that are known from expanded sections elsewhere.

The bioclastic sediments above the Phosphatic Chalk Hardground are clearly the equivalent of the non-phosphatic, but otherwise similar shell-detrital chalks that range in northern Germany (where they are known as the 'Grobkreide facies') from the top of the Upper Santonian

Marsupites Zone into the lower part of the succeeding Lower Campanian *Gonioteuthis granulataquadrata* Zone (Ernst, 1963). The Grobkreide facies is relatively weakly expressed in equivalent Southern Province basinal chalks. At the **Newhaven to Brighton** and **Cuckmere to Seaford** GCR sites, it begins in the higher part of the *Marsupites* Zone, above the hardgrounds beneath the Brighton Marl, and extends a short distance above the *Uintacrinus anglicus* Zone. The Winterbourne Phosphatic Chalk Hardground and Upper Hardground can be inferred to equate, respectively, with the hardground(s) below the Brighton Marl and with the hardgrounds with common *Echinocorys scutata tectiformis* at the upper limit of the oyster-rich chalks (cf. Wood and Mortimore, 1988, fig. 18). The abundance of belemnites above the Upper Hardground is typical of phosphatic chalks elsewhere (Jarvis, 1980b), and is in marked contrast to their rarity in coeval basinal chalks. The absence of *Belemnitella praecursor* Stolley from the assemblage suggests that the succession does not extend up to the *praecursor* event at the base of the *Gonioteuthis quadrata* Zone, and that the associated *Offaster pilula* relate more to the lower rather than to the higher of the two *Offaster* belts in the *pilula* Zone (see also West Harnham Chalk Pit and Newhaven to Brighton GCR site reports, this volume).

It is also noteworthy that the two main hardgrounds appear to be at the same stratigraphical position as hardgrounds 1 and 2 respectively, of the so-called ‘flintless belt' (Rowe, 1908) in the succession in the **Whitecliff** GCR site on the eastern side of the Isle of Wight (cf. Mortimore and Pomerol, 1997, fig. 9). This condensed succession, comprising an anomalous flintless belt with hardgrounds, reflects Late Santonian–Early Campanian structural control of sedimentation associated with the development of a pericline (the Sandown Pericline) over the northward extension of the major NW–SE Bray basement lineament of the Paris Basin. This interval of tectonic activity belongs to the Wernigerode Phase of Subhercynian tectonism (Stille, 1924) (see Mortimore and Pomerol, 1997; Mortimore *et al*., 1998).

The relationship between the Winterbourne Chalk Pit section and the stratigraphically somewhat lower **Boxford Chalk Pit** succession is unclear, despite the mapping evidence presented by White and Treacher. Those authors suggested (1906, figs 3, 4) that non- or only very weakly-phosphatic chalk belonging to the *Uintacrinus socialis* Zone was intercalated between the phosphatic chalks of the two localities. They also showed (White and Treacher, 1906, fig. 2) that the Chalk succession in the Boxford–Winterbourne area formed a synclinal structure that was truncated by Tertiary strata. The Boxford and Winterbourne sites both show condensed and/or attenuated successions with hardgrounds, as well as units of relatively low-grade phosphatic chalk. The extent of the condensation at Winterbourne Chalk Pit is shown by thicknesses of 9 m and 6–7 m respectively for poorly flinty *Uintacrinus* Zone and *Marsupites* Zone chalk near Kintbury, only 8 km to the south-west (White, 1907). The *pilula* Zone in Winterbourne is also remarkably thin compared with the succession in the Layland's Green Chalk Pit, near Kintbury (SU 386 667) (White, 1907), where some 9 m of flinty chalk belonging to this zone were recorded below an indurated iron-stained bed that may well mark the boundary with the overlying *Gonioteuthis quadrata* Zone.

Occurrences of Santonian–Campanian phosphatic chalk are concentrated on the northern side of the Anglo-Paris Basin, and are typi- cally associated with condensed successions preserved in single or stacked erosional troughs (‘cuvettes') which have been incised into normal white chalks. The typical cuvette is floored by a basal hardground and is filled by pelletal phosphate-rich chalks that either pass up gradually into, or are relatively abruptly succeeded by, normal non-phosphatic chalks (Jarvis, 1980a, 1992). One or more additional cuvettes, each with its own fill of phosphatic chalk, may then be incised into the filled initial cuvette. Jarvis and Woodroof (1981) discussed the application of this model to the **Boxford Chalk Pit** and Winterbourne Chalk Pit occurrences and concluded that, unlike the situation at **South Lodge Pit** (see GCR site report, this volume), it was not possible to identify either the basal hardground or the position of a cuvette with any confidence. In particular, the mapping-based inference of normal or virtually normal soft, white, flinty, *Uintacrinus* Zone chalks (White and Treacher, 1906) intercalated between the phosphatic chalk of the two localities is difficult to reconcile with the need for a basal hardground to the Winterbourne Chalk Pit occurrences. In any case, the phosphatic chalks at the latter site are relatively low in phosphate (rarely reaching 5% (Jarvis and Woodroof, 1981)), compared with the more typical phosphate-rich chalk at **South Lodge Pit**. Jarvis and Woodroof (1981) suggested that Winterbourne Chalk Pit might possibly have been situated on the margin of a former (unidentified) cuvette, which subsequently was removed by erosion. Their preferred explanation, of intra-formational structural control of sedimentation, broadly agrees with the present authors' interpretation, but considerable further investigation is required in order to understand the structural and depositional relationships. In particular, it should be pointed out that condensed successions containing a hardground overlain by concentrations of *Echinocorys scutata tectiformis*, comparable with the Boxford Upper Hardground, are not restricted to the immediate Boxford–Winterbourne area, but are also found at Kintbury.

Conclusions

Winterbourne Chalk Pit is a key locality for studying the stratigraphy and sedimentology of phosphatic chalks in the Santonian Stage and Early Campanian Substage in England. The abundance of crinoids, echinoids and belemnites provides the evidence for correlation of the main hardground surfaces with the Isle of Wight and more widely in Europe.

Reference list

Ernst, G. (1963) Stratigraphische und gesteinschemische Untersuchungen im Santon und Campan von Lägerdorf (SW-Holstein). Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg, **32**, 71–127.
Ernst, G. (1964) Ontogenie, Phylogenie und Stratigraphie der Belemnitengattung Gonioteuthis Bayle aus dem nordwestdeutschen Santon/Campan. Fortschritte in der Geologie von Rheinland und Westfalen, **7**, 487–94.
Jarvis, I. (1980a) The Initiation of Phosphatic Chalk Sedimentation – the Senonian (Cretaceous of the Anglo-Paris Basin). The Society of Economic Paleontologists and Mineralogists Special Publication, No. 29, 167–92.
Jarvis, I. (1980b) Palaeobiology of Upper Cretaceous belemnites from the phosphatic chalk of the Anglo-Paris basin. Palaeontology, **23**, 889–914.
Jarvis, I. (1992) Sedimentology, geochemistry and origin of phosphatic chalks: the Upper Cretaceous deposits of NW Europe. Sedimentology, **39**, 55–97.
Jarvis, I. and Woodroof, P.B. (1981) The phosphatic chalks and hardgrounds of Boxford and Winterbourne, Berkshire – two tectonically controlled facies in the late Coniacian to early Campanian (Cretaceous) of southern England. Geological Magazine, **118**, 175–87.
Mortimore, R.N. and Pomerol, B. (1997) Upper Cretaceous tectonic phases and end Cretaceous inversion in the Chalk of the Anglo-Paris Basin. Proceedings of the Geologists' Association, **108**, 231–55.
Mortimore, R.N., Wood, C.J., Pomerol, B. and Ernst, G. (1998) Dating the phases of the Subhercynian tectonic epoch: Late Cretaceous tectonics and eustatics in the Cretaceous basins of northern Germany compared with the Anglo-Paris Basin. Zentralblatt für Geologie und Paläontologie, Teil 1, **1996**, (11/12), 1349–1401.
Rowe, A.W. (1908). The Zones of the White Chalk of the English Coast. V. The Isle of Wight. Proceedings of the Geologists' Association, **20**, 209–352.
Stille, H. (1924) Grundfragen der vergleichenden Tektonik, Borntraeger, Berlin, 443 pp.
White, H.J.O. (1907) The Geology of the Country around Hungerford and Newbury, Memoir of the Geological Survey of Great Britain (England and Wales) New Series, Sheet 267, HMSO, London, 150 pp.
White, H.G.O. and Treacher, L. (1906) Phosphatic Chalks of Winterbourne and Boxford (Berkshire). Quarterly Journal of the Geological Society of London, **62**, 499–521.
Wood, C.J. and Mortimore, R.N. (1988) Chalk biostratigraphy. In Geology of the Country around Brighton and Worthing, (eds B.Young and R.D. Lake), Memoir of the British Geological Survey (England and Wales) Sheets 318 and 333, HMSO, London, pp. 58–64.