BOXFORD CHALK PIT

OS Grid Reference: SU431719

Introduction

Boxford Chalk Pit is an abandoned and partly overgrown chalk pit situated 300 m NNE of Boxford Church, on the east side of a minor road (Figure 4.7). The site is of critical importance in demonstrating the effects of biostratigraphically well-constrained intra-formational tectonism, erosion and slumping in the Chalk. It can be compared to the structurally complex **Downend Chalk Pit** GCR site, but the sedimentary anomalies there result from a later phase of Late Cretaceous tectonism. Together with the nearby GCR sites of **Winterbourne Chalk Pit**, and **South Lodge Chalk Pit** at Taplow, near Maidenhead, Boxford Chalk Pit contributes towards an understanding of the distinctive, and highly fossiliferous, phosphatic chalk lithofacies. This facies is particularly strongly developed in local erosional channels in the Chalk of northern France, and the site in some respects provides a miniature analogue of one of the last extant French phosphatic chalk quarries.

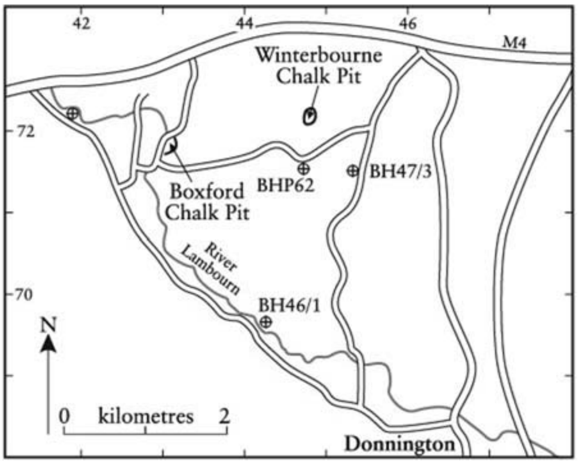

Figure 4.7: Location of Boxford Chalk Pit and Winterbourne Chalk Pit in the River Lambourn valley north of Newbury. (BH=Boreholes with geophysical logs that extend the stratigraphy to the Chalk Rock and below.)

Description

The succession at Boxford Chalk Pit comprises a relatively undisturbed (autochthonous) Lower Unit (Figure 4.8) of soft white flinty chalks with minor hardgrounds, which is itself capped by a pair of hardgrounds (Boxford Paired Hardgrounds). In contrast to the regional dip of only a few degrees to the SSE, the strata in the Lower Unit exhibit a significantly steepened, anomalous, dip of 25º in the same direction; evidence of this steepening of the dip is first seen 500 m to the north-east at Westbrook Farm Pit (SU 427 723), where dips of 5º – 6º have been recorded. The autochthonous unit is overlain, above a basal slide-plane, by a highly disturbed and displaced (allochthonous) Upper Unit comprising components of the autochthonous unit (Figure 4.8). The highest part of the section exposes a hardground (Upper Hardground – a cemented channel floor) with phosphatic chalk above (Figure 4.8).

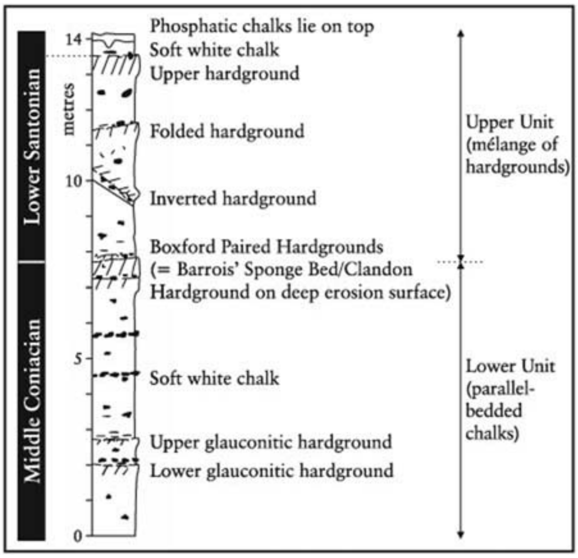

Figure 4.8: Stratigraphy at Boxford Chalk Pit. Hardgrounds, channels and slump beds in the Seaford Chalk Formation. (After Jarvis and Woodruff, 1981, fig. 2.)

The initial description of the site (White and Treacher, 1906) was based on a largely overgrown exposure. Hawkins (1924) described a better exposed section after the pit had been re-opened and he made the first attempt to interpret the complex structure. Jarvis and Woodruff (1981) provided the first detailed stratigraphical log when the pit was excavated by the Nature Conservancy Council in 1980. Subsequently Gale (1990b) revised the Jarvis and Woodroof section and provided a new structural interpretation. The pit has recently (1999) been re-excavated by English Nature.

Lithostratigraphy

The succession (Figure 4.8) can be divided into three distinct units (Jarvis and Woodroof, 1981, figs 2, 3; Gale, 1990b, figs 2, 3).

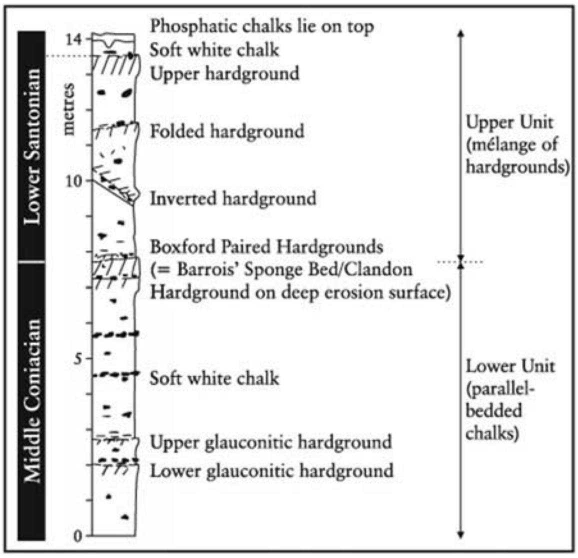
Figure 4.8: Stratigraphy at Boxford Chalk Pit. Hardgrounds, channels and slump beds in the Seaford Chalk Formation. (After Jarvis and Woodruff, 1981, fig. 2.)

The Lower Unit comprises a fossiliferous succession of soft white flinty chalk, which includes several hardgrounds and terminates in a closely spaced pair of hardgrounds. Jarvis and Woodroof (1981) recognized two poorly lithified glauconitized hardgrounds, 0.75 m apart, in the middle part of the succession, which they termed the 'Boxford Lower Glauconitic Hardground' and the 'Boxford Upper Glauconitic Hardground' respectively. They reported that large pieces of inoceramid bivalve shell and a rich macrofauna occurred above the higher of the two hardgrounds. Gale (1990b, fig. 2) indicated that the lower, flint-strewn hardground was more clearly defined than the upper one and identified an additional mineralized surface (his horizon 2) some 2 m below. A trench in the talus at the extreme base of the section revealed a strongly lithified, 0.3 m thick hardground (Gale, 1990b, fig. 2, horizon 1); this is weakly glauconitized, with a patchy shiny phosphate veneer.

The lowest unit terminates in a pair of indurated and weakly glauconitized hardgrounds, 0.3–0.5 m apart, which Jarvis and Woodroof termed the 'Boxford Paired Hardgrounds'. These hardgrounds and the intervening chalks are strongly stained with limonite, the development of very closely spaced sub-horizontal Liesegang diffusion bands imparting a spurious appearance of primary sedimentary lamination. The interval between the hardgrounds progressively reduces towards the northern part of the quarry. The upper of the hardgrounds is much more strongly lithified than the lower. It has a planar surface with a light brown, polished phosphate skin, and is penetrated by a *Thalassinoides* burrow system with glauconitized and phosphatized walls.

The overlying Upper Unit (allochthonous unit), as interpreted by Gale (1990b), consists of the terminal portion of a slump, comprising a folded and partly overturned repetition of the beds of the lower unit, and terminating in a single hardground (upper hardground) with a brown phosphate skin (Figures 4.8 and 4.9). Distal to the essentially coherent, albeit fragmented slump, are disordered chalk and hardground fragments. The slump is incorporated in coarsely bioclastic chalk, which includes several high-angle to sub-vertical sheet-flints. The terminal upper hardground, which is exposed over a distance of about 6 m, was interpreted by Gale as representing a lateral equivalent of the paired hardgrounds of the lower unit, which here have coalesced.

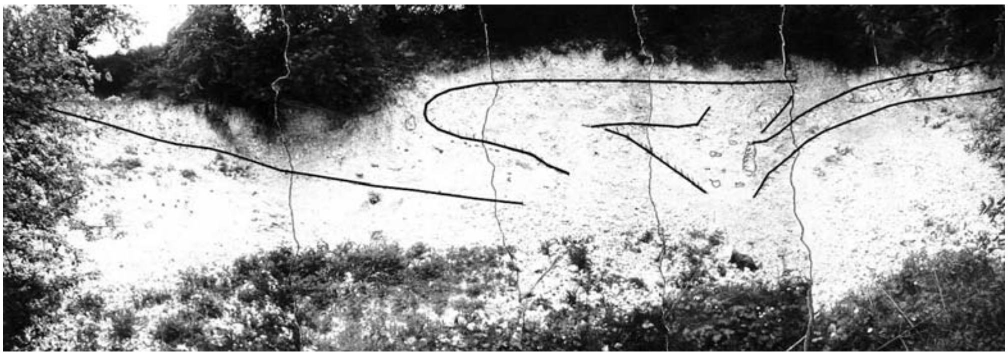

Figure 4.9: Boxford Chalk Pit, Berkshire, showing the outlines of the slump-folded hardgrounds. Width of section illustrated, approximately 10 m. (Based on photographs kindly supplied by Professor A. Gale.)

The highest unit comprises a development of phosphatic chalk. Jarvis and Woodroof (1981) described this unit as occupying a 4 m wide broad concave channel at the top of the northern end of the face. The phosphatic chalk is concentrated in poorly defined burrows within a less strongly phosphatic chalk matrix. The channel is floored by the glauconitized upper hardground and is overlain by phosphatized and glauconitized intraclasts. The phosphatic chalk fill terminates in a minor, sub-horizontal, glauconitized hardground that partly spans the concavity of the channel, and is itself overlain by intraclasts and hard-ground fragments. Jarvis and Woodroof (1981) described this second hardground as being syndepositionally fractured, with the sub-vertical fracture surfaces encrusted by oysters. However, Gale (unpublished data) has recorded highly fossiliferous phosphatic chalks directly resting on the paired hardgrounds in a position distal to the toe of the slump constituting the Upper Unit. It is unclear how this occurrence relates to the channel described by Jarvis and Woodroof.

Biostratigraphy

The entire succession below the Boxford Paired Hardgrounds (Figure 4.8), including the glauconitic hardgrounds of the Jarvis and Woodroof section and the unnamed lowest hardgrounds in the Gale section, yields specimens of the inoceramid bivalves *Volviceramus* and

Platyceramus. It therefore falls in the lowest (Middle Coniacian) part of the *Micraster coranguinum* Zone, the equivalent of the Belle Tout Beds of the standard Southern Province succession. Jarvis and Woodroof (1981) reported that large pieces of inoceramid shell and a rich macrofauna occurred above the Boxford Upper Glauconitic Hardground. *Micraster coranguinum* (Leske) itself was stated by White and Treacher (1906) to be common in the 2 m of chalk then exposed below the Paired Hardgrounds. They also noted that the surfaces of the large flints contained asteroid ossicles, as well as debris of regular echinoids and inoceramid shells. From the Paired Hardgrounds they recorded terebratulid brachiopods and siphonal tubes of the teredine bivalve *Teredo amphisboena* (Goldfuss). There is no evidence, either in the chalk below the Paired Hardgrounds, or in the hardgrounds themselves, of the basal Santonian event beds with the inoceramid bivalve *Cladoceramus undulatoplicatus* (Roemer).

The phosphatic chalks recorded at the northern end of the quarry are extremely fossiliferous, and have yielded common *Conulus*, as well as a rich, but unpublished, mesofauna of microbrachiopods and selachian teeth. White and Treacher (1906) additionally listed *Micraster* and several species of cidarids but, surprisingly, there was no record of *Echinocorys*, nor of the common *Conulus* noted by Gale. This phosphatic chalk lies in direct superposition on the Boxford Paired Hardgrounds at one point, and it can tentatively be inferred to represent the highly fossiliferous terminal (Santonian) part of the *coranguinum* Zone, including one or more horizons with abundant *Conulus*, that is found above the Barrois Sponge Bed of the Isle of Thanet and the Clandon Hardground in the North Downs respectively.

Interpretation

It can be inferred that the Paired Hardgrounds equate with the (Middle Santonian) Barrois' Sponge Bed of the **Thanet Coast** GCR site, and with the correlative, and much more strongly lithified Clandon Hardground of the North Downs (see p. 308). However, in marked contrast to the situation at West Clandon Quarry near Guildford, the type locality of the Clandon Hardground, where erosion prior to hardground formation cut down to a level a short distance above Whitaker's 3-inch Flint Band (Robinson, 1986), pre-hardground erosion has removed the greater part of the *coranguinum* Zone. The Boxford Paired Hardgrounds collectively represents a lithified surface within the Belle Tout Beds.

The initial description of the complex succession by White and Treacher (1906) was based on a largely overgrown exposure. They clearly identified the Boxford Paired Hardgrounds (their Bed 2), and some 2 m of the underlying autochthonous unit (Bed 1). The higher part of their descriptive log is less easy to interpret, although the coarse-grained, non-phosphatic chalks of their Bed 3 (*c*. 4 m) and the oyster-rich phosphatic chalks with angular brown and light green concretions of Bed 4 (*c*. 3 m) can be inferred to represent broadly the allochthonous slumped beds and the phosphatic chalks respectively. They additionally observed that the hardground was overlain by a thin seam of grey rubbly marl and that the basal part of the overlying chalk contained a high content of fragmented bioclastic debris.

Hawkins (1924) described the better-exposed section that was revealed when the pit was re-opened. He provided an accurate record of the lower part of the autochthonous unit, down to a level immediately above the Upper Glauconitic Hardground. In his view, some poorly exposed, northerly dipping hardgrounds in the allochthonous unit represented the southern part of a syncline that had been telescoped and forced northwards over the Paired Hardgrounds of the autochthonous unit, which formed the northern limb of the same fold. However, it is difficult to reconcile his section (Hawkins, 1924, fig. 34) of the allochthonous unit with those recorded by Jarvis and Woodroof (1981) and by Gale (1990b).

Jarvis and Woodroof (1981) recorded and illustrated (their fig. 3) several detached lengths of hardgrounds at various orientations within the displaced (allochthonous) Upper Unit, which they termed the 'inverted', 'inclined' and 'folded' hardgrounds respectively (Figures 4.8 and 4.9). They considered that the highest hardground (their upper hardground), situated high in the face, was entirely unrelated to any of the hardgrounds and hardground fragments below. Gale (1990b), on the other hand, re-interpreted their section on the basis of identifying several of the lengths of hardground as components of the autochthonous succession, and equated the single upper hardground with the otherwise similar Paired Hardgrounds. In his interpretation, the distinctive overturned 'folded' hardground of the Jarvis and Woodroof section represented the more strongly lithified (Lower) of the Glauconitic Hardgrounds (compareJarvis and Woodroof, 1981, fig. 3, with Gale, 1990b, fig. 1), with the 'inverted' and 'inclined' hardgrounds representing lower hardgrounds within the same succession (Figure4.8). Gale regarded the allochthonous unit as double, with the higher component, comprising the coalesced equivalent of the paired hardgrounds, together with the immediately underlying soft chalk, being separated by a slide-plane from the lower component, which was itself separated by a slide-plane (White and Treacher's 'grey marl') from the relatively undisturbed (autochthonous) Lower Unit (Figure 4.8).

Boxford Chalk Pit provides an analogue in miniature of the Beauval phosphatic chalk Quarry in Picardy, northern France. At the latter locality, the basal hardground below the phosphatic chalks locally contains *Cladoceramus* (e.g. Jarvis, 1992, fig. 2), demonstrating that erosion prior to hardground formation had cut down to the base of the Santonian succession. Elsewhere in the same quarry, erosion has cut considerably deeper, and the hardground represents lithification of a surface within Middle Coniacian chalks with *Volviceramus*, as in the case of the relationship between the Boxford Paired Hardgrounds and the underlying chalks.

The dating of the sedimentary anomalies at Boxford Chalk Pit is difficult to determine. It is also not easy to interpret them entirely in terms of the erosional channel (cuvette) model advanced by Jarvis (1980a, 1992) for other phosphatic chalk occurrences in the Anglo-Paris Basin. Westbrook Farm Pit exposes relatively gently dipping unfossiliferous standard flinty *coranguinum* Zone chalk (Upper Coniacian). Traced laterally from there towards Boxford Chalk Pit, the fossiliferous Middle Coniacian *coranguinum* Zone succession is incomplete, condensed and strongly dipping in the Boxford Chalk Pit autochthonous Lower Unit. A possible cause of this lateral change is the existence, close to Boxford, of an intra-Coniacian growth structure controlled by underlying faulting.

If the Boxford Paired Hardgrounds (Figure 4.8) are correctly interpreted as being the equivalent of the Middle Santonian Barrois' Sponge Bed/Clandon Hardground, then the depth of erosion at Boxford points to strong local structural control of this inter-regional intra-Santonian erosive event as well. Elsewhere the Clandon Hardground lithifies various levels within both the Santonian and Coniacian portions of the *coranguinum* Zone. The fact that the hardground is itself caught up in the allochthonous Upper Unit at Boxford Chalk Pit suggests that sliding of lithified sediment on a (structurally induced?) palaeoslope also took place at an even later date.

Structurally controlled anomalies of this type are typically associated with a position over or adjacent to NW–SE-aligned basement faults that were re-activated during the Late Cretaceous Epoch, following the switchover from a tensional to a compressive stress field. The anomalous sedimentation at Boxford Chalk Pit can be broadly placed within the sequence of Ilsede and early Wernigerode phases of Subhercynian tectonic events (Stille, 1924) recently described from both the European platform and from the Southern Province and Anglo-Paris Basin (see Mortimore and Pomerol, 1997; Mortimore *et al*., 1998).

The structural and depositional relationship between the Boxford Chalk Pit succession and the phosphatic chalk succession of the nearby **Winterbourne Chalk Pit** is unclear, but is further discussed within the GCR site report (this volume).

Conclusions

Boxford Chalk Pit is unique in exposing Middle Coniacian to Lower Santonian major erosion surfaces and slump beds in the English Chalk. Abundant key index inoceramid bivalves and echinoids provide the evidence for detailed correlation of these events.

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