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Dinoflagellate cyst biostratigraphy of the Coniacian–Santonian (Upper Cretaceous): New data from the English Chalk

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Abstract

Results are presented here for the first chalk-based, high-resolution quantitative study of organic-walled dinoflagellate cysts (dinocysts) from the entire Coniacian–Santonian Chalk successions in east Kent and on the Isle of Wight. The lithostratigraphy and dinocyst records (137 taxa) of seven sections are presented, and the stratigraphic ranges of taxa are constrained relative to stage and zonal boundaries, located using extensive macrofossil data. Results are integrated with a previous complementary study of the Isle of Wight Santonian to test and refine existing dinocyst bioevent schemes. Sixteen dinocyst events are proposed as a sequence of biostratigraphic datum levels for the lower Coniacian to uppermost Santonian which, based on average sedimentation rates, represent an average temporal resolution of around 360 kyr. The event stratigraphy forms a basis for the first high-resolution correlation study of quantitative dinocyst data from the Upper Cretaceous of NW Europe. A new genus *Culversphaera* Prince, Jarvis, Pearce et Tocher *gen. nov.* is proposed with the new combination *Culversphaera velata* Prince, Jarvis, Pearce et Tocher *gen. et comb. nov.* Five new species: *Ellipsodinium membraniferum* Prince, Jarvis, Pearce et Tocher *sp. nov., Senoniasphaera macroreticulata* Prince, Jarvis, Pearce et Tocher *sp. nov.*, *Senoniasphaera whitenessii* Prince, Jarvis, Pearce et Tocher *sp. nov.*, *Xenascus spinatus* Prince, Jarvis, Pearce et Tocher *sp. nov.* and *X. yunii sp. nov.*, and the new subspecies *S. protrusa congrensa* Prince, Jarvis, Pearce et Tocher *subsp. nov.* are described.

Keywords: dinoflagellate cysts; Upper Cretaceous; biostratigraphy; chalk; Coniacian; Santonian

1. Introduction

Ammonites are rare or absent from most Coniacian–Santonian Chalk sections in NW Europe, and established macrofossil zones rely predominantly on the first and last appearance datum levels of echinoid, crinoid and inoceramid bivalve index taxa. These groups also provide the internationally-agreed basis for defining the bases of the Coniacian, Santonian and Campanian Stages and their constituent substages. However, despite being easily identifiable, the generally benthic habit of these groups limits the spatial distribution of individual species and compromises correlation between different facies belts and between different faunal realms. Macrofossils are also of little use in dating core and cuttings samples routinely recovered in petroleum exploration programmes. Planktonic foraminiferal index species, widely used for the zonation of tethyan pelagic successions, are rare or absent in northern European chalks, and benthic species, although abundant, show marked provincialism. Calcareous nannofossils may be poorly preserved and do not always display consistent ranges on a regional scale.

Organic-walled dinoflagellate cysts (dinocysts) have proven to be one of the most useful groups in biostratigraphy, due in part to their high diversity and phytoplanktonic affinity, a

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significant rate of species turnover, and their excellent preservation in both carbonate and siliciclastic facies. However, published quantitative high-resolution studies of NW European Upper Cretaceous dinocyst stratigraphy remain scarce, severely limiting the use of dinocysts for dating, correlation and palaeoenvironmental interpretation.

The pioneering work of Clarke and Verdier (1967) on dinocyst events from the Lower Cenomanian–Campanian Chalk of the Isle of Wight (southern England), which for over 30 yr represented the key reference for Late Cretaceous dinocyst biostratigraphy, has been significantly improved recently by a high-resolution study of the Santonian to lower Campanian interval by Prince et al. (1999). To extend the dinocyst event stratigraphy proposed by Prince et al. (1999), new data are presented here from the Coniacian of the Isle of Wight, further complementing the work of Clarke and Verdier (1967). The resulting Coniacian–Campanian dinocyst event stratigraphy derived from the Isle of Wight is tested and refined by comparison with data obtained from a composite Coniacian to lower Campanian section in Kent (SE England).

This paper presents results of the first high-resolution (1-m sampling interval) multiple-section study of Coniacian–Santonian dinocysts based on precisely located samples. A detailed knowledge of the pertinent lithostratigraphy and macrofossil biostratigraphy of the area is fundamental to constrain the sections in a precise stratigraphic framework; these aspects are reviewed for the seven localities forming the basis of the present study. Palynological results are used to propose a new dinocyst event stratigraphy that offers potential for improved regional correlation, with some events likely having a much wider stratigraphic significance. Future comparison of our results with those from other chalk successions, together with an evaluation of associated sedimentological, biotic and geochemical palaeoenvironmental proxies, should provide a sound basis for further work.

1.1. Choice of study sections

The white cliffs of Dover provide the archetypical view of the southern English coastline. These sections were the focus of the first detailed lithological description and subdivision of the British Chalk by Phillips (1818, 1821) in the early nineteenth century. Subsequent work in the area (Whitaker, 1865a; Dowker, 1870; Whitaker et al., 1872; Hébert, 1874; Barrois, 1876; Hill, 1886; Rowe, 1900; Jukes-Browne and Hill, 1903, 1904) led to the Kent coast sections (Fig. 1) becoming a reference for much subsequent Upper Cretaceous research (e.g. Jefferies, 1963; Kennedy, 1969; Jarvis et al., 1988a; Gale, 1989), due largely to the abundance and high quality of the macrofossils that can be collected.

Macrofossil data from Kent has provided key evidence for defining the positions of Upper Cretaceous stage boundaries, both in Europe and beyond (e.g. Gale and Woodroof, 1981; Bailey et al., 1983, 1984; Gale et al., 1995, 2002). A stable-isotope study tied to detailed lithostratigraphic logs by Jenkyns et al. (1994) led to the east Kent Cenomanian–Santonian succession becoming an international reference for carbon- and oxygen-isotope stratigraphy (e.g. Voigt and Hilbrecht, 1997; Wiese, 1999; Wiese and Kaplan, 2001; Coccioni and Galeotti, 2003; Hasegawa et al., 2003), and their data were used recently by Jarvis et al. (2006) to help construct a $\delta^{13}C$ composite reference curve for the Cenomanian–Campanian.

The spectacular sections of the eastern Isle of Wight (Fig. 1) were also described by many early Chalk workers (Whitaker, 1865b; Barrois, 1875a, 1876; Strahan, 1889; Jukes-Browne and Hill, 1904; Rowe, 1908; Brydone, 1914). They represent the most complete single section through the Chalk in southern England, extending from the Cenomanian to the upper Campanian. Here the chalks are more indurated due to deeper burial and Tertiary tectonism, making them less suitable for macrofossil collecting, despite containing abundant fauna at many levels. Jenkyns et al. (1994) presented a detailed log and stable-isotope data for the Campanian at Whitecliff.

Extensive micropalaeontological studies based largely on benthic foraminifera have focussed particularly on Kent and the Isle of Wight (Carter and Hart, 1977; Bailey and Hart, 1979; Hart, 1982; Hart et al., 1989). Calcareous nannofossils have been described from Kent and the Isle of Wight by Crux (1982) and Burnett et al. (1999). Clarke and Verdier (1967) studied the Upper Cretaceous dinoflagellate cyst biostratigraphy of the Isle of Wight. Unfortunately, with a few notable exceptions (Tocher and Jarvis, 1987, 1995; Jarvis et al., 1988a,b; FitzPatrick, 1995; Prince et al., 1999, Pearce et al., 2003; Hampton et al., 2007), the majority from the Cenomanian - Turonian interval, most micropalaeontological sampling of the Chalk has not been tied to detailed lithostratigraphic logs or precisely located relative to macrofossil datum levels, severely limiting its effective stratigraphic resolution.

1.2. Lithostratigraphic framework

Phillips (1818, 1821) divided the Chalk at Dover into informal units and subunits based on the abundance of flint and "organic remains". Whitaker (1865a) and Whitaker et al. (1872) subsequently recognised that the Chalk on the Isle of Thanet to the NE (Fig. 1) was stratigraphically higher than that at Dover, and introduced the names "Broadstairs Chalk" and "Margate Chalk" to describe that part of the succession, although it was realised that the former was probably partly equivalent to the uppermost of Phillips subdivisions, 'the Chalk with numerous flints and few organic remains' (Phillips, 1818, 1821). Dowker (1870) gave formal names: Dover Chalk; St Margaret's Chalk; and Ramsgate Chalk, to the upper three of Phillip's units, retaining the Margate Chalk for the top of the succession. A modified version of this scheme was used by Barrois (1876), who confirmed that the Broadstairs Chalk was equivalent to (and therefore had historical priority over) the Ramsgate Chalk.

Coincident with the early lithostratigraphic studies, macrofossil assemblage biozones established for the Chalk of NW France by Hébert (1863) were shown to be equally applicable in southern England (Hébert, 1874; Barrois, 1876; Hill, 1886). Subsequently, following the detailed biostratigraphic work of Rowe (1900, 1901, 1903, 1906a,b, 1904, 1908, 1929) and Jukes-Browne and Hill (1903, 1904), lithostratigraphic terms