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Review paper

Applied palaeontology in the Chalk Group: quality control for geological mapping and modelling and revealing new understanding

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ABSTRACT

The Chalk is a major aquifer, source of raw material for cement and agricultural lime, and a host geological unit for major civil engineering projects. Detailed understanding of its development and lateral variation is significant for our prosperity and for understanding the potential risks of pollution and groundwater flooding, and in this aspect palaeontology plays a central part. Historically, the distribution of macrofossils offered important refinement to the simple three-fold subdivision of the Chalk based on lithological criteria. In recent decades, the advent of a more sophisticated lithostratigraphy for the Chalk, more closely linked to variations in its physical properties, provided an impetus for the British Geological Survey to depict this on its geological maps. Tracing Chalk stratigraphical units away from the well-exposed successions on which the new stratigraphy is based requires subtle interpretation of landscape features, and raises the need for methods of ensuring that the interpretations are correct. New and archived palaeontological data from the vast BGS collections, interpreted as a component of a broad-based holostratigraphical scheme for the Chalk, and spatially analysed using modern Geographical Information Systems (GIS) and landscape visualisation technology, helps fulfil this need. The value of palaeontological data in the Chalk has been boosted by the work that underpins the new lithostratigraphy; it has revealed broad patterns of biofacies based on a range of taxa that is far more diverse than those traditionally used for biostratigraphy, and has provided a detailed reference framework of marker-beds so that fossil ranges can be better understood.

In the subsurface, biofacies data in conjunction with lithological and geophysical data, has been used to interpret and extrapolate the distribution of Chalk formations in boreholes across southern England, allowing development of sophisticated three-dimensional models of the Chalk; revealing the influence of ancient structures on Chalk depositional architecture, and pointing to palaeoenvironmental factors that locally affected productivity of Chalk in Late Cretaceous oceans.

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1. Introduction

Geology is now widely recognised as vital to our economic prosperity. It provides us with raw materials for manufacturing, sources of water and energy, and provides foundations for our infrastructure. The Chalk has a wide outcrop across the densely populated area of south-east England, and is peppered with boreholes for water supply; quarried for cement and agricultural lime, and hosts many large scale civil engineering structures, such as the Channel Tunnel. Understanding variation in the thickness and distribution of the Chalk, and how its physical properties vary, are vital requirements for future economic and population development across southern England, and fossils play an important part in delivering this understanding.

Historically, fossils have always had an important role in Chalk geology. The substantial thickness and apparent physical uniformity of the Chalk presented early workers with the problem of how to subdivide it on geological maps. The simple three-fold classification into Lower, Middle and Upper Chalk that became the traditional classification, defined at feature-forming beds of hard chalk, persisted into the latter part of the twentieth century, but presented problems for detailed understanding of internal variation. In contrast, macrofossils appeared to provide a basis for detailed subdivision of outcropping Chalk successions that could better describe its spatial distribution and age relationships, and regional biozonal maps were published for the Chalk by Brydone (1912), Gaster (1924, 1929, 1932, 1937, 1941, 1944), Young (1905, 1908), Hewitt (1924, 1935) and Peake and Hancock (1970). Some historical accounts even described units containing particular fossil assemblages as if they were distinct lithological entities; for example, use of the term 'Marsupites Chalk' by Dines and Edmunds (1929) in the Geological Survey Memoir for Aldershot and Guildford. As outlined by Gale and Cleevely (1989), this fixation on palaeontology by early Chalk workers stemmed largely from the highly influential publications of Arthur Rowe. In his description of coastal sections (Rowe, 1900, 1901, 1903, 1904, 1908), Rowe emphasised the value of fossils for subdividing the Chalk and often criticised the use of lithological criteria. The position of fossils at the heart of Chalk geology was further bolstered by confusion of some of the marker-beds used to recognise the traditional units, and observed inconsistencies in the stratigraphical horizons of these markers (Jukes-Browne, 1880; Rowe, 1901, 1908).

The last 30 years, spurred on by economic imperatives requiring a better understanding of variation in the Chalk's physical properties, has seen a revolution in the geology of the Chalk, including the advent of a detailed national lithostratigraphical scheme (Rawson et al., 2001; Hopson, 2005) recognised across southern England on recent British Geological Survey (BGS) maps. Whilst this new Chalk classification emphasises differences in physical character that are of particular value to engineers and hydrogeologists, the exhaustive work on outcrop sections that has been required to produce it has revealed important relationships between macrofossils and lithostratigraphy. With a robust scheme of Chalk formations, defined by surfaces or marker-beds that in many cases are the products of basin-wide events, it has become easier to understand broad patterns of macrofossil occurrences. This new understanding of the palaeontology of the Chalk, and the adoption of a *holostratigraphical* approach which integrates different kinds of geological data to arrive at best-fit interpretations, has proved invaluable for helping to understand the surface distribution of different units of Chalk in poorly exposed terrain, and in tracing the distribution of these units in the subsurface for geological modelling.

This work shows how macrofossil palaeontology remains a valuable tool in our understanding of the distribution, correlation and basin structure of the Chalk Group, not in spite of lithostratigraphy, but because of it.

2. Biostratigraphy in the context of Chalk Group holostratigraphy

Between 1999 and 2006, the BGS released digital reports describing the holostratigraphy of the Upper Silurian Ludlow Series (Molyneux, 1999; http://www.bgs.ac.uk/reference/holostrat/ludlow.html) and the Lower Cretaceous Albian Stage (Wilkinson, 2006; http://www.bgs.ac.uk/reference/holostrat/albian.html), and a manuscript was prepared for the Chalk Group,

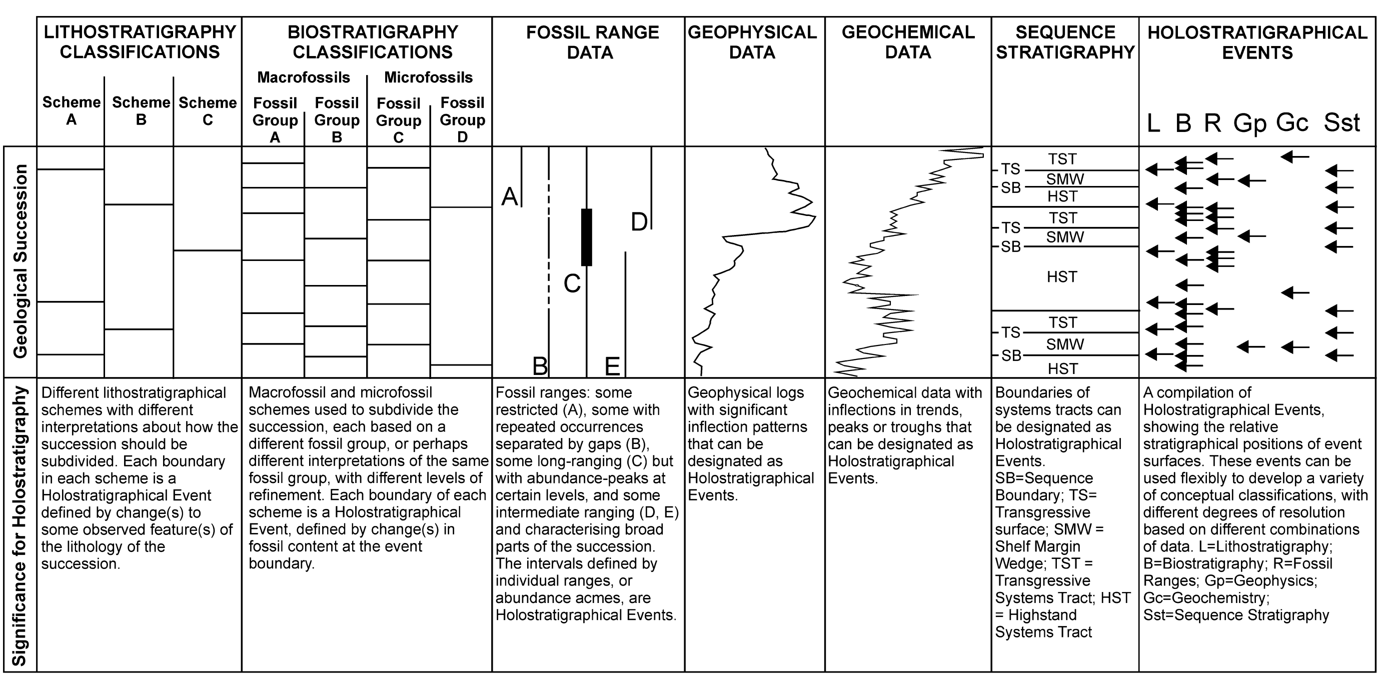

Fig. 1. Examples of data types and their use in Holostratigraphy.