British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

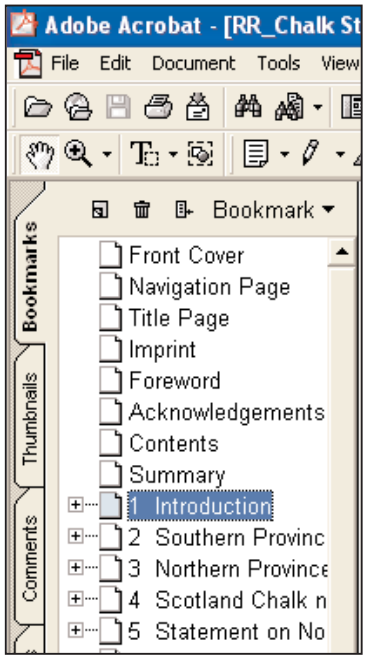
A stratigraphical framework for the Upper Cretaceous Chalk of England and Scotland with statements on the Chalk of Northern Ireland and the UK Offshore Sector

Research Report RR/05/01

HOW TO NAVIGATE THIS DOCUMENT

Bookmarks

The main elements of the table of contents are bookmarked enabling direct links to be followed to the principal section headings and sub-headings, figures, plates and tables irrespective of which part of the document the user is viewing.



In addition, the report contains links:

- from the principal section and sub-section headings back to the contents page,
- from each reference to a figure, plate or table directly to the corresponding figure, plate or table,
- from each figure, plate or table caption to the first place that figure, plate or table is mentioned in the text and
- from each page number back to the contents page.

RETURN TO CONTENTS PAGE

BRITISH GEOLOGICAL SURVEY

RESEARCH REPORT RR/05/01

A stratigraphical framework for the Upper Cretaceous Chalk of England and Scotland with statements on the Chalk of Northern Ireland and the UK Offshore Sector

Keywords

Geology, Statigraphy, Upper Cretaceous, Chalk

Front cover

Chalk cliff and the Pinnacles stacks south of Handfast Point, north-east of Swanage, Dorset.

Bibliographical reference

HOPSON, P M. 2005. A stratigraphical framework for the Upper Cretaceous Chalk of England and Scotland, with statements on the Chalk of Northern Ireland and the UK Offshore Sector. *British Geological Survey Research Report* RR/05/01 102pp.

ISBN 0 85272 517 5

P M Hopson

Keyworth, Nottingham British Geological Survey 2005

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desks at Nottingham, Edinburgh and London; see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications including maps for consultation.

The Survey publishes an annual catalogue of its maps and other publications; this catalogue is available from any of the BGS Sales Desks.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter is an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

Keyworth, Nottingham NG12 5GG
☎ 0115–936 3100 Fax 0115–936 3200
e-mail: sales @bgs.ac.uk
www.bgs.ac.uk
Online shop: www.geologyshop.com

Murchison House, West Mains Road, Edinburgh EH9 3LA
☎ 0131–667 1000 Fax 0131–668 2683
e-mail: scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE
☎ 020–7589 4090 Fax 020–7584 8270
☎ 020–7942 5344/45 e-mail: bgslondon@bgs.ac.uk

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU
☎ 01392–445271 Fax 01392–445371

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF
☎ 028–9038 8462 Fax 028–9038 8461

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB
☎ 01491–838800 Fax 01491–692345

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff, CF15 7NE
☎ 029–2052 1962 Fax 029–2052 1963

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU
☎ 01793–411500 Fax 01793–411501

Foreword

The Stratigraphy Committee of the British Geological Survey (BGS) is undertaking a review of stratigraphical classification for all parts of Great Britain. Several Stratigraphical Framework Committees (SFC) have been established to review problematical issues for various parts of the stratigraphical column. Each SFC has the following terms of reference:

- to review the lithostratigraphical nomenclature of designated stratigraphical intervals for a given region, identifying problems in classification and correlation
- to propose a lithostratigraphical framework down to formation level
- to organise a peer review of the scheme
- to present the results in a document suitable for publication
- to ensure that full definitions of the lithostratigraphical scheme are held in the web-accessible BGS Stratigraphical Lexicon for the areas of responsibility covered by the SFC

This report is the published product of a study by the British Geological Survey Stratigraphical Framework Committee (BGSSFC) for the Upper Cretaceous of Great Britain. The report provides a summary of the lithostratigraphical schemes for the five Upper Cretaceous provinces in England (Southern, Transitional and Northern), Scotland and Northern Ireland.

In November of 1999 a meeting held at the BGS in Keyworth, co-sponsored by the BGS and the Stratigraphy Commission of the Geological Society, brought together experts on the Chalk to standardise the nomenclature on BGS maps and to act as a framework for the new Cretaceous correlation publication of the Geological Society. This report follows the recommendations of that meeting for the English Chalk and includes reviews and proposals for the terminology utilised in Scotland and Northern Ireland.

BGS Stratigraphical Framework reports are published in collaboration with the Stratigraphy Commission of the Geological Society through the BGS Internet www.bgs.ac.uk where they are available as free downloads. Reports are peer reviewed via the Stratigraphy Commission.

Acknowledgements

This document is the statement on the stratigraphical terminology of the Chalk Group presented to the BGS Stratigraphical Framework Committee and Stratigraphy Commission of the Geological Society. It contains a review of the nomenclature currently used in BGS publications and maps and sets out the terms to be utilised within current and future BGS publications. This statement draws heavily on the work of BGS staff as well as contributions from the academic community and the deliberations of a meeting on Chalk Lithostratigraphy convened at the BGS in Keyworth by the Stratigraphy Commission of the Geological Society. In this context special mention should be made of Professor Peter Rawson, Professor Andy Gale, Professor Rory Mortimore, Dr Don Aldiss, Dr Roger Bristow, Dr A R Farrant, Mr Peter Hopson, Mr Mike Sumbler, Dr Ian Wilkinson, Mr Chris Wood, Mr Mark Woods, and, of course, all of the members of staff of the BGS who have special responsibility for the characterisation of the Chalk. The reviewers for the Geological Society are given thanks for their perceptive comments and corrections to the draft of this document.

Contents

Foreword iii

Acknowledgements iv

Summary vii

1 Introduction 1
- 1.1 History of research **1**
- 1.2 Review of present practice and usage in the BGS **6**

2 Southern Province Chalk nomenclature 8
- 2.1 Chalk Group **14**
  - 2.1.1 Grey Chalk Subgroup **15**
    - 2.1.1.1 West Melbury Marly Chalk Formation **16**
    - 2.1.1.2 Zig Zag Chalk Formation **18**
    - 2.1.1.3 Beer Head Limestone Formation **19**
  - 2.1.2 White Chalk Subgroup **20**
    - 2.1.2.1 Holywell Nodular Chalk Formation **21**
    - 2.1.2.2 New Pit Chalk Formation **22**
    - 2.1.2.3 Lewes Nodular Chalk Formation **23**
    - 2.1.2.4 Seaford Chalk Formation **25**
    - 2.1.2.5 Newhaven Chalk Formation **26**
    - 2.1.2.6 Culver Chalk Formation **27**
    - 2.1.2.7 Portsdown Chalk Formation **29**
    - 2.1.2.8 Upper Campanian and Maastrichtian Chalk in the Transitional Province **30**

3 Northern Province Chalk Nomenclature 31
- 3.1 Chalk Group **36**
  - 3.1.1 Grey Chalk Subgroup **36**
    - 3.1.1.1 Ferriby Chalk Formation **36**
  - 3.1.2 White Chalk Subgroup **36**
    - 3.1.2.1 Welton Chalk Formation **36**
    - 3.1.2.2 Burnham Chalk Formationn **38**
    - 3.1.2.3 Flamborough Chalk Formation **39**
    - 3.1.2.4 Rowe Chalk Formation **39**

4 Scotland Chalk nomenclature (Scottish Chalk Province) 41
- 4.1 Inner Hebrides Group **44**
  - 4.1.1 Morven Greensand Formation **44**
  - 4.1.2 Lochaline White Sandstone Formation **45**
  - 4.1.3 Coire Riabhach Phosphatic Formation **45**
  - 4.1.4 Gribun Chalk Formation **46**
  - 4.1.5 Strathaird Limestone Formation **46**
    - 4.1.5.1 Clach Alasdair Conglomerate Member **47**
    - 4.1.5.2 Laig Gorge Sandstone Member **47**
  - 4.1.6 Feorlin Sandstone Formation **48**
  - 4.1.7 Beinn Iadain Mudstone Formation **48**

5 Statement on Northern Ireland Chalk Nomenclature (Ulster Cretaceous Province) 49
- 5.1 Hibernian Greensands Group **51**
  - 5.1.1 Belfast Marls Formation **53**
  - 5.1.2 Island Magee Siltstones Formation **53**
  - 5.1.3 Collinwell Sands Formation **53**
  - 5.1.4 Kilcoan Sands Formation **54**
- 5.2 Ulster White Limestone Group **54**
  - 5.2.1 Pre-Larry Bane Chalk Subgroup **55**
    - 5.2.1.1 Cloghfin Sponge Formation **56**
    - 5.2.1.2 Galboly Chalk Formation **56**
    - 5.2.1.3 Cloghastucan Chalk Formation **57**
    - 5.2.1.4 Creggan Chalk Formation **57**
    - 5.2.1.5 Boheeshane Chalk Formation **58**
  - 5.2.2 Larry Bane Chalk Formation **58**
  - 5.2.3 Post-Larry Bane Chalk Subgroup **59**
    - 5.2.3.1 Ballintoy Chalk Formation **59**
    - 5.2.3.2 Glenarm Chalk Formation **60**
    - 5.2.3.3 Garron Chalk Formation **60**
    - 5.2.3.4 Portrush Chalk Formation **61**
    - 5.2.3.5 Ballymagarry Chalk Formation **61**
    - 5.2.3.6 Tanderagee Chalk Formation **62**
    - 5.2.3.7 Port Calliagh Chalk Formation **62**
    - 5.2.3.8 Ballycastle Chalk Formation **62**

6 Note on the Chalk Group Nomenclature in the UK offshore sector 64

9 References 66

FIGURES

1 The Upper Cretaceous ‘provinces’ for the United Kingdom **2**
2 Litho- and biostratigraphical correlation chart for the Chalk Group of Southern England **3**
3 Terminology applied to the Chalk of England **4**
4 The Chalk Group provinces of England **9**
5a The development of the terminology in the Southern Province **10**
5b The development of the terminology in south-east Devon (Southern Province) **11**
5c The development of the terminology in Norfolk (Transitional Province) **12**
6 The development of the terminology in the Northern Province **32**
7 The development of the terminology in the Scottish Chalk Province **42**
8 The Inner Hebrides Scottish Chalk Province **43**
9 The development of the terminology in the Ulster Cretaceous Province **50**
10 The Northern Ireland Cretaceous Province **51**

11 The development of the terminology in the offshore UK Sector **65**

TABLES

1 The agreed lithological framework from the Chalk Lithostratigraphy meeting held at BGS, Keyworth, on the 3–4 November 1999 (after Rawson, Allen and Gale, 2001) **6**
2 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of the Southern and Transitional provinces of England **14**
3 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of the Northern Province of England **36**
4 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of Scotland **41**
5 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of Northern Ireland **52**

APPENDIX

1 BGS sheets showing Upper Cretaceous strata **71**
2 Nomenclature terms used on published 1:50 000 scale BGS geological sheets in England and Scotland (s) **74**
3 Redundant terms on BGS maps and other schemes used in the ‘Southern Province’ **79**

Summary

In November of 1999 a meeting held at the BGS in Keyworth, co-sponsored by the BGS and the Stratigraphy Commission of the Geological Society, brought together experts on the Chalk to standardise the nomenclature on BGS maps and to act as a framework for the new Cretaceous correlation publication of the Geological Society. Agreement was reached, with some reservations, on a framework to guide future workers in Chalk research and the application of this should standardise terminology.

It was agreed that the Chalk Group should be divided into a Grey Chalk Subgroup and a White Chalk Subgroup on a national basis for England. The base of the Grey Chalk Subgroup being everywhere placed at an erosional contact that marks the base of the Upper Cretaceous; and the base of the White Chalk Subgroup being everywhere placed at the base of the Plenus Marls Member. In addition the meeting agreed that there were sufficient lithological and faunal differences to sustain a lithostratigraphical nomenclature at formational level (and below) for a 'Northern Province' and a 'Southern Province'. A 'Transitional Province' covers part of the Chilterns and much of East Anglia and here diagnostic lithologies and faunas characteristic of the Northern and Southern provinces interdigitate. It was the recommendation of the meeting that the appropriate nomenclature from either the Northern or Southern provinces be applied in the Transitional Province although it is generally the case, based on historic records, that the 'southern' terms can be applied widely. The lack of modern surveying and the opportunity to assess the chalk at outcrop over much of the East Anglia region has meant that the highest preserved chalks on the UK mainland (representing the upper Campanian to lower Maastrichtian stages), for which various schemes have been proposed, have not been studied in terms of their mappability and the informal terms Norwich Chalk and Trimmingham Chalk are adopted herein as an interim measure.

This framework accorded with the best practise of the BGS surveying activities throughout the Chalk Group of England, with the proviso that, in the Southern Province, the terms 'Lower, Middle and Upper Chalk formations' were abandoned; that the 'members' being utilised as mapping units (after Bristow et al. 1997) should be redesignated as formations; and that the Holywell Nodular Chalk Formation, newly created as a consequence, should include the Plenus Marls Member as its basal unit. A Plenus Marl Member is also defined for the Northern Province at the base of the Welton Chalk Formation to provide continuity between the provinces. In the case of the Hunstanton Formation the consensus in the meeting was that it was a formation, but not part of the newly defined Chalk Group, and as defined it is older than the major hiatus at the base of the Cenomanian (a definition is included for completeness).

A summary of that unified scheme, its relationship to earlier schemes and definitions of each term are given herein. Beyond formational level, members of historical value or local significance, some of which are traceable over unexposed countryside and therefore deemed to be 'mappable', are also defined. Reference is also given to the principal lithostratigraphical schemes of earlier authors and correspondence of their terms to this new scheme given where it can be determined. **It is strongly recommended that in future local variations in lithology that are deemed sufficiently mappable and provide additional data on the structure and distribution of the Chalk be formally designated as members within the formational schemes erected here. It would not be necessary for any given formation to be divided entirely into members**.

The schemes for Scotland and Northern Ireland are discussed in the light of the most recent publications and it is suggested that they be referred to as the Scottish Chalk Province and the Ulster Cretaceous Province. **It is confirmed herein that formal schemes be adopted for both areas with the following provisos**. In the case of Scotland formations are defined within an Inner Hebrides Group. Whilst in the case of Northern Ireland the Hibernian Greensand and Ulster White Limestone formations are upgraded to group level with two subgroups to divide the Ulster White Limestone and numerous formations created by upgrading the presently defined members within both groups. In both provinces lithological variation is rapid within and between basins and sub-basins that are heavily influenced by extensional tectonics associated with the opening of the Atlantic Ocean. By adopting the formation as the basic unit, new research will be able to define local variations at member level.

Stratigraphies for the UK offshore sector are well documented elsewhere and only a summary is included here to demonstrate the correspondence between the onshore and offshore schemes.

1 Introduction

This document is the formal statement on the stratigraphy of the Chalk Group as adopted by the British Geological Survey and ratified by the BGS Stratigraphical Framework Committee and the Stratigraphy Commission of the Geological Society. It contains a review of the nomenclature currently used in BGS publications and maps and makes proposals for a new scheme. This review draws heavily on the work of BGS staff as well as contributions from the academic community and the deliberations of a meeting on Chalk Lithostratigraphy convened at the BGS in Keyworth by the Stratigraphy Commission of the Geological Society.

The document is mainly concerned with the successions outcropping in the southern and eastern part of England from Devon to Kent, in East Anglia, and in Lincolnshire and Yorkshire. Within the English outcrop Northern and Southern provinces are well established in the literature (strictly these should be referred to, for example, as the Northern Chalk Province etc., although most of the literature omits the chalk descriptor), separated by an informal Transitional Province that includes the Chilterns and East Anglia (Figure 1). The concept of a Transitional Province is less meaningful in the light of the proposed lithostratigraphical terminology for the Northern and Southern provinces, whose defined terms should be used wherever possible across the transition. However these provinces are a useful concept and should not be abandoned as they are defined principally on the basis of their faunal content (the biostratigraphical Boreal Realm [northern] and Tethyan Realm [southern] respectively). Other less easily defined factors such as the influence of the Anglo-Brabant Massif on sedimentological processes, physical properties of the chalk and the interdigitation of diagnostic lithologies and faunas characteristic of the Northern and Southern provinces are also a feature of the transition. Whilst the Tethyan Realm is richly fossiliferous and has an agreed international standard biostratigraphy based on planktonic foraminifera its relationship to the Boreal Realm is only tenuously correlated at many levels and further justifies the separation of the Northern and Southern provinces. Indeed the general absence of planktonic forms has led to a benthonic foraminiferal scheme being developed for the UK (Figure 2).

The limited outcrops in Scotland (Scottish Chalk Province) are also discussed and a proposal to formalise the nomenclature within the Inner Hebrides Group and based on the most modern literature is included.

For Northern Ireland (Ulster Cretaceous Province), there is a well-established lithostratigraphy but it is proposed herein to raise the status of the units defined by one level thus creating the Hibernian Greensand Group and the Ulster White Limestone Group with various subgroups and formations. These two groups are effectively the mapping units since there are only limited outcrops of the Cretaceous succession at the margin of the overlying Palaeogene basalts. In both provinces lithological variation is rapid within and between basins and sub-basins as a consequence of the heavy influence of extensional tectonics associated with the opening of the Atlantic Ocean. By adopting formation as the basic unit new research will be able to define local variations at member level without the need to demonstrate lateral continuity and mappability.

A brief statement of the terminologies used within the UK Offshore Sector is given in Section 6 and summarised in Figure 11.

1.1 HISTORY OF RESEARCH

The following text relies heavily on the following documents, but has been modified, to remove ambiguity and bias; a personal communication between Prof. Andy Gale and Peter Allen prior to the Chalk Lithostratigraphy meeting at Keyworth (Gale, 1999, pers. comm.); a review of the Chalk Group for Yorkshire and Lincolnshire prepared as a BGS Technical Report (Sumbler, 1999); the paper by Bristow et al. (1997); reviews of the Chalk of the South and North Downs (Aldiss, 2002) and (Hopson, 1999) respectively; and the most recently published Geological Conservation Review book by Mortimore et al. (2001).

The earliest lithostratigraphical divisions of the Chalk were provided W Phillips (1818, 1821) for Kent, by Mantell (1822) for Sussex, and by Woodward (1833) for Norfolk (Figure 3, Columns 1, 2 and 3[1] respectively). These schemes were based primarily on the clay content of the chalk and the relative abundance (or absence) of flints. These early classifications had a degree of agreement although the boundaries between units chosen by the authors differed.

These authors recognised a 'marly' lower unit termed the Grey Chalk, Grey Chalk Marl or Chalk Marl but always overlain by the Lower Chalk distinguished by its hardness and absence of flint. This lower 'marly' unit corresponds approximately with the subsequently devised 'traditional scheme' term of Chalk Marl (see below and (Figure 2, Column 1)) with or without the lower part of the Grey Chalk included (also part of the 'traditional scheme' nomenclature but not to be confused with the 'Grey Chalk' of W Phillips, 1818). Each of these schemes introduced an 'Upper Chalk' which was characterised by numerous flints. W Phillips and Woodward separated a unit at the base of the Upper Chalk as their Chalk with few flints or Medial Chalk. Similar schemes were utilised by Bogg (1816) for Lincolnshire and by J Phillips (1829) for Yorkshire.

It is interesting to note that the Lower–Middle Chalk boundary at the base of the Melbourn Rock, considered to be so distinctive nowadays, did not appear in these schemes. The use of a 'Lower Chalk' (incorporating the Chalk Marl/Grey Chalk) without flints and an 'Upper Chalk' with flints continued for much of the remainder of the 19th century (e.g. Whitaker, 1865b; Dowker, 1870)

1 Reference to the relevant Figure and column numbers showing the quoted scheme graphically will be given subsequently in the form (Figure x, Column y) where y refers to the column number.

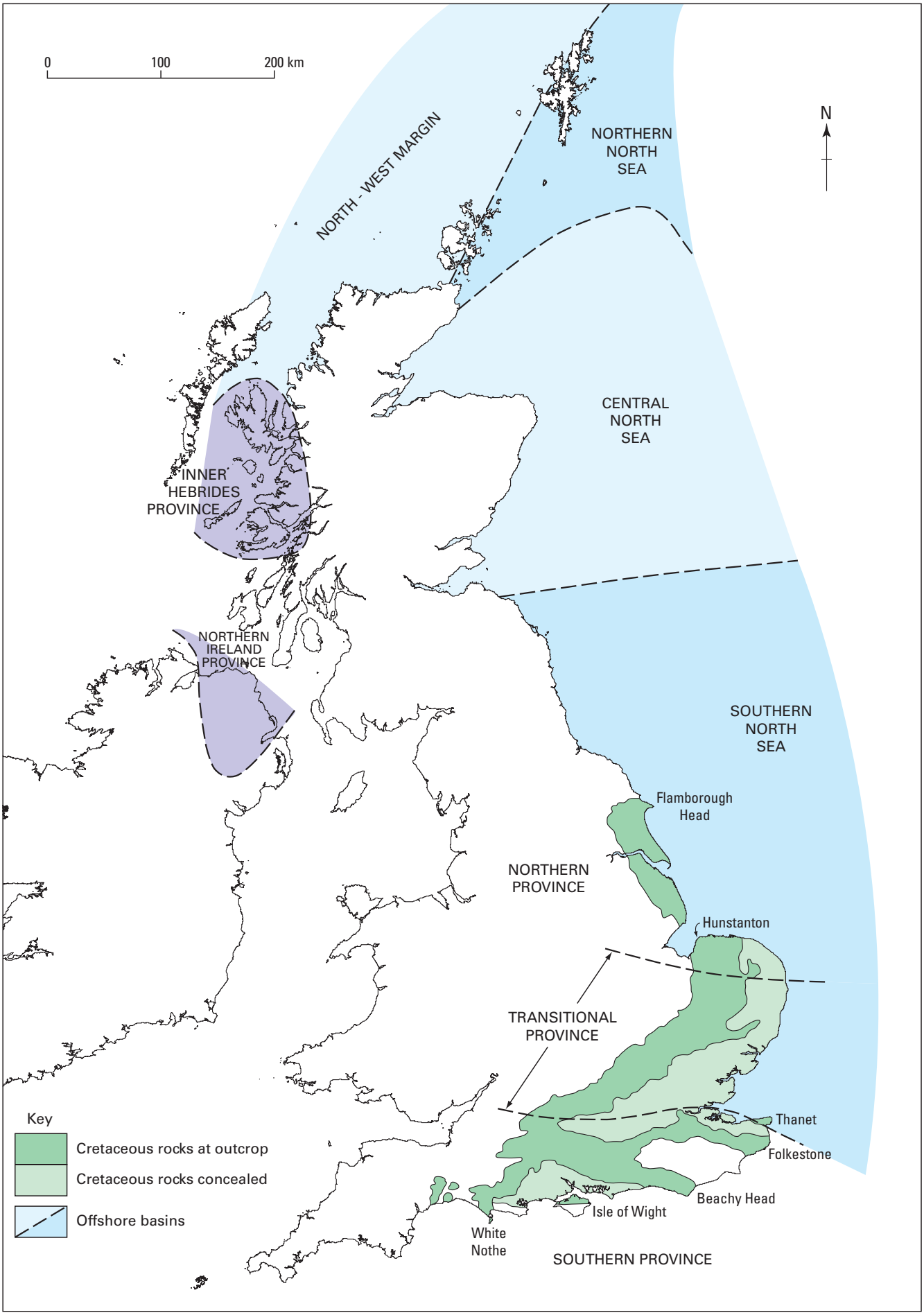


Figure 1 The Upper Cretaceous 'provinces' for the United Kingdom.

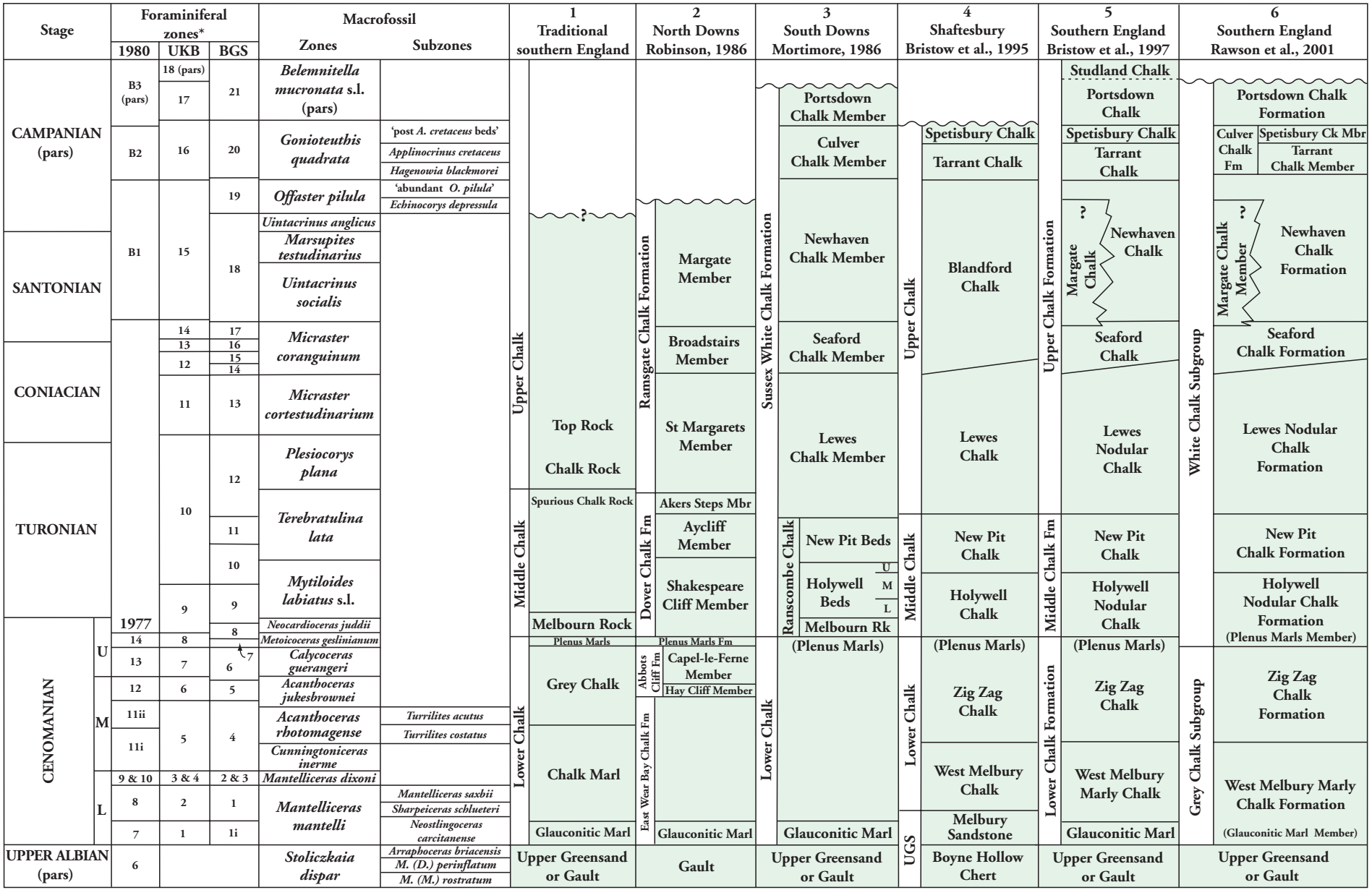


Figure 2 Litho- and biostratigraphical correlation chart for the Chalk Group of Southern England.

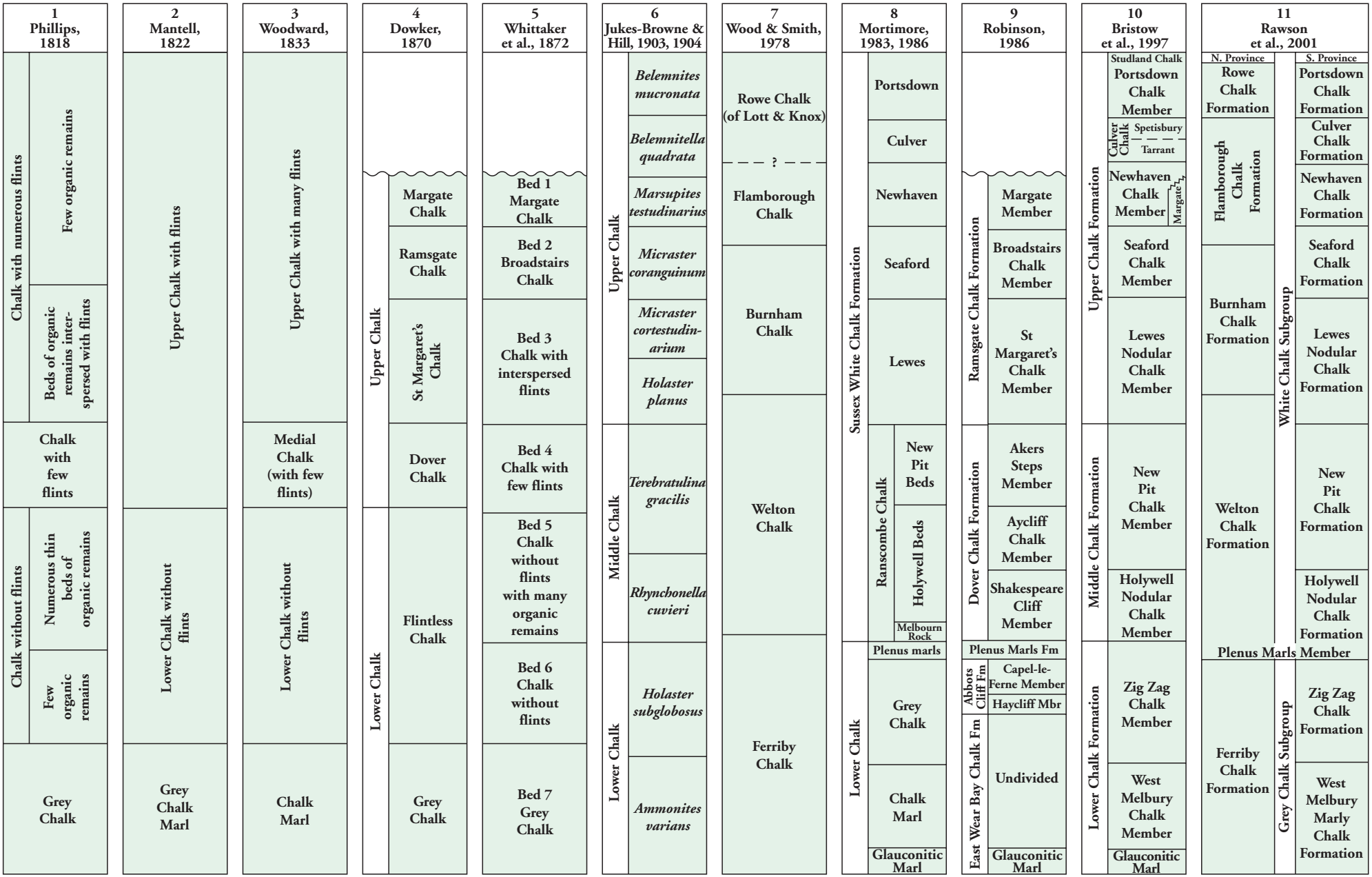


Figure 3 Terminology applied to the Chalk of England.

(Figure 3, Column 4 and Figure 5a, Column 2); (e.g. Whitaker, Bristow and Hughes, 1872) (Figure 3, Column 5 and Figure 5a, Column 3).

Sharpe (1853) was the first author to revise this system by placing the Chloritic Marl and the Chalk Marl within the Lower Chalk, and establishing a Middle Chalk characterised by a sparse fauna. In 1880, Jukes-Browne described the Melbourn Rock in Cambridgeshire, and Penning and Jukes-Browne (1881) used this feature-forming and easily traceable unit to divide their Lower from a new Middle Chalk unit. They also determined that a higher hard rock band, the Chalk Rock, containing a characteristic fauna and preservation style, formed a similar feature separating the Middle from the Upper Chalk (Figure 2, Column 1). An integrated bio- and lithostratigraphical scheme (the 'traditional scheme' herein) was developed in memoirs of the Geological Survey and presented in the seminal works of Jukes-Browne and Hill (1903, 1904) (Figure 3, Column 6, Figure 5a, Column 6, Figure 5b, Column 4 and Figure 6, Column 4) (*The 1904 volume also contains a comprehensive bibliography of published works on the Chalk in the period 1628 to 1903*). It is these two volumes that formed the basis of the Geological Survey's mapping of the Chalk of southern England until the 1990s and are the basis for the Geological Society's correlation of the 'Southern Province' Chalk (Rawson et al., 1978). Certain aspects of the 'traditional scheme' were, however, difficult to apply in mapping terms to the Chalk of Lincolnshire and Yorkshire and the Middle–Upper Chalk boundary, in particular, was a matter of some conjecture.

Rowe (1900 to 1908), working from a biostratigraphical premise, did not recognise the separate Middle and Upper Chalk divisions as they were based on what he saw as an ephemeral and diachronous lithological feature (the Chalk Rock). Instead he used the term 'White Chalk' to include both Middle and Upper Chalk of the 'traditional scheme'. This concept of the term 'White Chalk' was accepted by Mortimore (1983, 1986) (Figure 3, Column 8, Figure 2, Column 3 and Figure 5a, Column 9), if on somewhat different criteria, and he formally introduced the lithostratigraphical term of the 'Sussex White Chalk Formation'.

Bristow et al. (1997) (Figure 3, Column 10, Figure 2, Column 5, Figure 5a, Column 10) reintroduced a threefold terminology with Lower, Middle and Upper Chalk classed as formations, each redefined to include slightly different strata than before and designed to provide a basis for mapping and a connection to the 'traditional scheme'. These formations were further divided into newly defined members.

The threefold division was justified by using the base of the Lewes Chalk Member of Mortimore (1983) that could be widely mapped in southern England as the base of the Upper Chalk. Although it was recognised as a diachronous boundary marked by the onset of distinct nodularity, it corresponded approximately with the old Middle–Upper Chalk boundary. Gale and Hancock (1999), in correspondence, argued that this was an arbitrary division and Middle and Upper Chalks defined thus lacked lithological integrity. Their arguments were strongly refuted (Bristow et al., 1999) in correspondence in the same volume.

The first attempt last century to separate the litho- and biostratigraphy of the Chalk was by Wood and Smith (1978) who erected a new fourfold lithostratigraphical scheme for Yorkshire and Lincolnshire (Figure 3, Column 7 and Figure 6, Column 5). They established the Ferriby, Welton, Burnham and Flamborough Chalk formations. The Ferriby Formation is dominantly white chalk with marly partings overlying the Red Chalk. A thin but distinctive Black Band at the base of the overlying Welton Chalk Formation which commences with a marly unit (the Plenus Marls 'Member' of Witham, 1991 and others) is overlain by massive to thickly bedded chalks with flint nodules. The succeeding Burnham Chalk Formation comprises thinly bedded chalks with tabular and semi-tabular flints overlain by the essentially flint-free and softer chalks of the Flamborough Chalk Formation. This paper is particularly important in that it established the distinctive and separate lithological succession of the Chalk in Yorkshire and Lincolnshire for the first time. Lott and Knox (1994) (Figure 11, Column 4) working in the North Sea introduced the term Rowe Chalk Formation to cover the very highest Chalk concealed beneath Quaternary deposits in the Hornsea area and immediately offshore. Sumbler (1999) described these beds, based on geophysical logs from boreholes, as 70 m or so of flint-bearing chalks characterised by the inferred presence of *Belemnitella mucronata* (a species commonly reworked into the overlying Quaternary deposits) and also indicated that still younger beds were present offshore.

Formal lithostratigraphical schemes followed for the chalk successions of the Southern Province with proposals by Mortimore (1986) (Figure 5a, Column 9) for the South Downs, by Robinson (1986) (Figure 5a, Column 8) for the North Downs and by Jarvis and Woodroof (1984) (Figure 5b, Column 7], for the marginal facies in south-east Devon. The amalgamation of the Middle and Upper Chalk into 'White Chalk' as proposed by Rowe (1900 to 1908), was accepted by Mortimore (1983, 1986), who formally named the lithostratigraphical unit Sussex White Chalk Formation. This he divided into six members (and each into a number of 'beds'), which overlay a Lower Chalk Formation (undivided other than in terms of the 'traditional' named subdivisions). This division of the Sussex White Chalk Formation was based on the presence or absence of flints and marls, and the incidence of hard chalks or nodularity. In the North Downs, Robinson (1986) divided the Chalk Group into five lithostratigraphical formations, based on diverse criteria including the presence or absence of rhythmicity, flint, and clay content. Three formations formed the traditional Lower Chalk interval and two the remainder of the Chalk. With the exception of the thin 'Plenus Marl Formation' he divided each formation into members but left a large part of the 'East Wear Bay Chalk Formation' undivided. Developing the work of Mortimore, and consolidating the field-based observations by a large body of surveyors in the British Geological Survey during the 1990s, Bristow, et al. (1997) (Figure 3, Column 10, Figure 2, Column 5 and Figure 5a, Column 10) formally proposed a scheme for the lithostratigraphical mapping of the Chalk of the Southern Province.

In November of 1999 a meeting held at the BGS in Keyworth, co-sponsored by the BGS and the Stratigraphy Commission of the Geological Society, brought together experts on the Chalk to standardise the nomenclature on BGS maps and to act as a framework for the new Cretaceous correlation publication of the Geological Society. Agreement was reached, with some reservations, on a framework to guide future workers in

Chalk research and the application of this should standardise terminology. It was agreed that the Chalk Group should be divided into a Grey Chalk Subgroup and a White Chalk Subgroup on a national basis. The base of the Grey Chalk Subgroup being everywhere placed at an erosional contact that marks the base of the Upper Cretaceous; and the base of the White Chalk Subgroup being everywhere placed at the base of the Plenus Marls Member. In addition the meeting agreed that there were sufficient lithological and faunal differences to sustain a lithostratigraphical nomenclature at formational level (and below) for a Northern Province and a Southern Province (see Table 1).

This accorded with the best practise of the BGS surveying activities at the time, with the proviso that the 'Lower, Middle and Upper Chalk Formations' were abandoned; that the 'members' being utilised as mapping units (after Bristow et al., 1997) in the Southern Province should be redesignated as formations; and that the Holywell Nodular Chalk Formation, newly created as a consequence, should include the Plenus Marls Member as its basal unit. A summary of that unified scheme, and its relationship to earlier schemes, is shown in Figure 3, Column 11, Figure 2, Column 6 and Figure 5a, Column 11. Beyond formational level, members of local significance, some of which may prove to be traceable over unexposed countryside and therefore deemed to be 'mappable', can be erected without the need for any given formation to be divided entirely into members. It is strongly recommended herein that local variations in lithology that are deemed sufficiently mappable and provide additional data on the structure and distribution of the Chalk be formally designated as members within the formational scheme erected here.

To aid the understanding of the changes in terminology used in BGS publications over time, and the relationship between those terms and the unified scheme, a comprehensive Lexicon of informal/formal and current/redundant terms will be developed by the BGS. It follows that as BGS maps come up for revision, whether in paper or digital format, the new terminology will be adopted.

1.2 REVIEW OF PRESENT PRACTICE AND USAGE IN THE BGS

At present many BGS publications base their interpretation of the Chalk of England on the 'traditional scheme' (Figure 2, Column 1) and, within the most recent output, on the various stages of the development of the new lithostratigraphical schemes.

As maps come up for revision the traditional scheme is being replaced by the most appropriate Southern or Northern Province nomenclature (see Sections 2 and 3 respectively). Thus, for some years the scheme exemplified within Wood and Smith (1978) (Figure 3, Column 7 and Figure 6, Column 5) and later workers in Lincolnshire and Yorkshire has been used instead of the traditional scheme of Jukes-Browne and Hill (1903, 1904) (Figure 3, Column 6 and Figure 5a, Column 6). South of The Wash through East Anglia and into southern England (with the exception of the most north-westerly outcrops that have used elements of the Northern Province terminology) the traditional scheme held sway until well into the 1990s. That traditional nomenclature is being comprehensively replaced by the scheme developed on the Wincanton (297), Shaftsbury (313) (Figure 2, Column 4) and Chichester (317/332) 1:50 000 scale sheets and later formalised in the paper by Bristow et al., (1997) (Figure 3, Column 10, Figure 2, Column 5 and Figure 5a, Column 10). The most recent maps such as Winchester (299) in the Southern Province use nomenclature recommended in Rawson et al., (2001) (Figure 3, Column 11, Figure 2, Column 6 and Figure 5a, Column 11) which is a development of the earlier Bristow et al., (1997) paper.

It follows that there are a large number of lexicon entries, which require full descriptions so that both the traditional scheme and the various iterations of the new terminology can be adequately understood. It is recommended that henceforth the new approved scheme be used for all England and Wales BGS maps and publications. There should be no need to vary terminology within the new framework, but it is envisaged that entirely

Table 1 The agreed lithological framework from the Chalk Lithostratigraphy meeting held at BGS, Keyworth, on the 3–4 November 1999 (after Rawson, Allen and Gale, 2001).

		Southern Province		Northern Province	
Stage	**Subgroup**	**Formation**	**Member**	**Formation**	**Member**
Campanian	White Chalk	Portsdown Chalk		Rowe Chalk	
		Culver Chalk	Spetisbury Chalk	Flamborough Chalk	
			Tarrant Chalk		
Santonian		Newhaven Chalk			
		Seaford Chalk			
Coniacian		Lewes Nodular Chalk		Burnham Chalk	
Turonian		New Pit Chalk		Welton Chalk	
		Holywell Nodular Chalk			
Cenomanian			Plenus Marls		Plenus Marls
	Grey Chalk	Zig Zag Chalk		Ferriby Chalk	
		West Melbury Marly Chalk			

new terms will only be required at member level (for which full lexicon entries will be required) as investigations proceed. In other circumstances the new group and formation terminology should be adhered to even if this means that amalgamations of strata (e.g. Lewes Nodular Chalk and Seaford Chalk formations, undifferentiated) are mapped to accommodate either the available field data or the type of map (e.g. full survey, revision, desk study). As time progresses the traditional scheme entries will become redundant in terms of the new maps and reports published.

In Scotland the extremely condensed succession preserved beneath 'Tertiary' basalts, has been assigned, by the Survey, to a simple informal nomenclature: Morvern Greensand, Loch Aline Glass Sand and Silicified Limestone that has more in common with the Upper Cretaceous of Northern Ireland than England. Braley (1990) and Lowden et al., (1992) (Figure 7, Column 6) introduced a number of formations within an 'Inner Hebrides Group' to encompass all of the Cretaceous (implying an Albian age for the lowest beds) rocks of north-west Scotland. Emeleus (1997) in the Rum memoir followed this nomenclature. The recently published Geological Conservation Review volume (Mortimore et al., 2001) (Figure 7, Column 7) completely revised the terminology for the Scottish outcrops (formalising many existing terms but with the proviso that the dating of the sequence proposed by Braley was uncertain). As yet this scheme has not been tested by mapping. A digest of the terminology is added to the discussions in Section 4 (see Figure 8).

The scheme for Northern Ireland has been well established following the work of Fletcher (1977) (Figure 9, Column 6) with the two principal units being designated as the Hibernian Greensands Formation and overlying it, the Ulster White Limestone Formation. Each are divided into members. A brief outline of the Northern Ireland Upper Cretaceous succession is given below (Section 5). It is the recommendation of this report that it is now time to upgrade the framework for Northern Ireland by raising the status of the presently defined formations to group and the present members to formation. Thus permitting other workers the greater latitude for the naming of stratal units at member and bed levels in detailed investigations.

A note on offshore nomenclature developed in response to hydrocarbon investigations since the early 1960s is included at the end of this report and in Figure 11.

Appendices 1 and 2 give an appraisal of the terms used on BGS onshore geological maps available at the 1:50 000 and 1:63 360 scales. Appendix 3 gives the Lexicon style definitions for the redundant terminology used in older BGS publications and a listing of lithostratigraphical terms used in key papers from which the current terminology has been derived. Where possible cross-reference is made to redundant terms commonly used in the literature.

2 Southern Province Chalk nomenclature

The palaeogeographical and structural features affecting the Chalk of the Southern Provinces are shown in Figure 4. The **Chalk Group** has been in use informally for a number of years. Its first formal use was by Rhys (1974) (Figure 11, Column 1) to cover the Chalk in the North Sea and by Wood and Smith (1978) (Figure 3, Colulmn 7 and Figure 6, Column 5) to cover the whole of the Chalk succession in the Northern Province but this also included the Red Chalk (now excluded from the definition as the Hunstanton Formation). Rawson et al., (1978) used the term Chalk Formation to cover the whole of the Chalk (Cenomanian to Maastrichtian). Robinson (1986) (Figure 3, Column 9, Figure 2, Column 2 and Figure 5a, Column 8) in the North Downs and Mortimore (1986) (Figure 3, Column 8, Figure 2, Column 3 and Figure 5a, Column 9), by implication, in the South Downs, used the term Chalk Group to cover the succession from the basal unconformity to the youngest known chalk beneath the Palaeogene unconformity in those areas. Bristow et al. (1997) (Figure 3, Column 10, Figure 2, Colulmn 5 and Figure 5a, Column 10) used Chalk Group to include Lower, Middle and Upper Chalk formations. Rawson et al., (2001) (Figure 3, Column 11, Figure 2, Column 6 and Figure 5a, Column 11) formalised the terminology, agreed at the November 1999 meeting, using Chalk Group to cover a lower Grey Chalk Subgroup and a higher White Chalk Subgroup. These divided further into formations.

It should be emphasised that the use of the Southern Province terms throughout the Transitional Province must be tested as these areas come up for revision. It is known with some certainty that Southern Province formations can be readily applied throughout the Chilterns and northwards into Cambridgeshire within the scarp facing west over the River Ouse/Wash Basin. The continuity of these formations beneath the thick Quaternary superficial deposits to the east and north needs to be tested. Geophysical borehole records and the interpretations of Murray (1986) show that there is a continuity of widespread identifiable marl seams in Essex, southern Suffolk and further north which confirm a framework of events that are correlated to marker beds in the Southern Province. Of course these geophysical results show inflections interpreted as marls and do not give comprehensive information on the nature of the intervening chalk lithologies. These lithologies need to be characterised to be certain of the use of Southern Province terms but it is envisaged that the formational framework may still be applied widely beneath East Anglia; and that variations in chalk successions may be better attributed to locally named units. It is suggested that such units as are identified be designated as members principally because their 'mappability' beneath the Quaternary cover may merely reflect an inappropriate borehole spread unrelated to their true extent.

A digest of the development of terminology in the Southern Province (and for the south-east Devon and Norfolk sequences) is given in Figures 5a to c.

The **Grey Chalk Subgroup** is defined as the succession from the basal Cenomanian unconformity up to the base of the Plenus Marl Member of the succeeding White Chalk Subgroup. It comprises two formations, a lower West Melbury Marly Chalk Formation and an upper Zig Zag Chalk Formation with the boundary between placed at the base of the Cast Bed. Historically this succession has been included within the Lower Chalk which itself has been further subdivided. A short review of the development of the terminology for this subgroup is given below.

In the earlier part of the 19th century, the terms Grey Chalk, Chalk Marl or even the combination of Grey Chalk Marl were applied generally to the lowest part of what is now called the Grey Chalk Subgroup. The 'Grey Chalk' of W Phillips (1818) (Figure 5a, Column 1) is approximately coincident with the lower three-quarters of the Grey Chalk Subgroup as presently understood. The presence of Chloritic Marl at the base of the chalk succession was recognised by Forbes and Ibbetson in 1844 (see Jukes-Browne and Hill, 1903).

In 1877, Price used a classification of the Lower Chalk at Folkestone that separated marly (more clayey) Chalk Marl from an overlying more carbonate-rich Grey Chalk (not to be confused with the 'Grey Chalk' of W Phillips). This scheme was used in his classification of the Lower Chalk by Jukes-Browne and Hill (1903) [Geological Survey memoir on the 'Lower and Middle Chalk of England']. They retained selected traditional lithological names from the 19th century, including Chloritic Marl, Chalk Marl, Totternhoe Stone and Grey Chalk, and introduced two faunal zones in the Lower Chalk; a lower *Schloenbachia varians* Zone (equivalent to the Chloritic Marl and Chalk Marl) overlain by the *Holaster subglobosus* Zone (Grey Chalk and Belemnite Marl [Plenus Marls Member in present usage]). They noted that the lithological divisions could not be recognised everywhere; for example, the succession equivalent to the Chalk Marl of south-east England comprises hard white and grey chalk containing little clay in north Norfolk, Lincolnshire and Yorkshire (see following section). Furthermore, they did not recognise the Totternhoe Stone (or equivalent) south of the Thames, making separation of the Chalk Marl and Grey Chalk very difficult south and west of Berkshire. They circumvented problems posed by these lateral variations in lithology by describing only the corresponding biostratigraphical divisions in areas where the Chalk Marl and Grey Chalk could not be separated lithologically. However, where possible, Survey memoirs referred to lithological units and a fourfold division at 'member' level was widely recognised in England, south of north-west Norfolk: Glauconitic (Chloritic in early texts) Marl, the Chalk Marl, the Grey Chalk and the Plenus Marls.

An upwards decrease in clay content (of 10 to 20%) from the Chalk Marl to the Grey Chalk occurs gradationally over a considerable (but laterally variable) thickness of the succession and the boundary can be difficult to recognise especially in incomplete inland exposures. In the Boulonnais of northern France, this difficulty has been overcome by the creation of a separate formation for the transitional unit. In Berkshire and farther

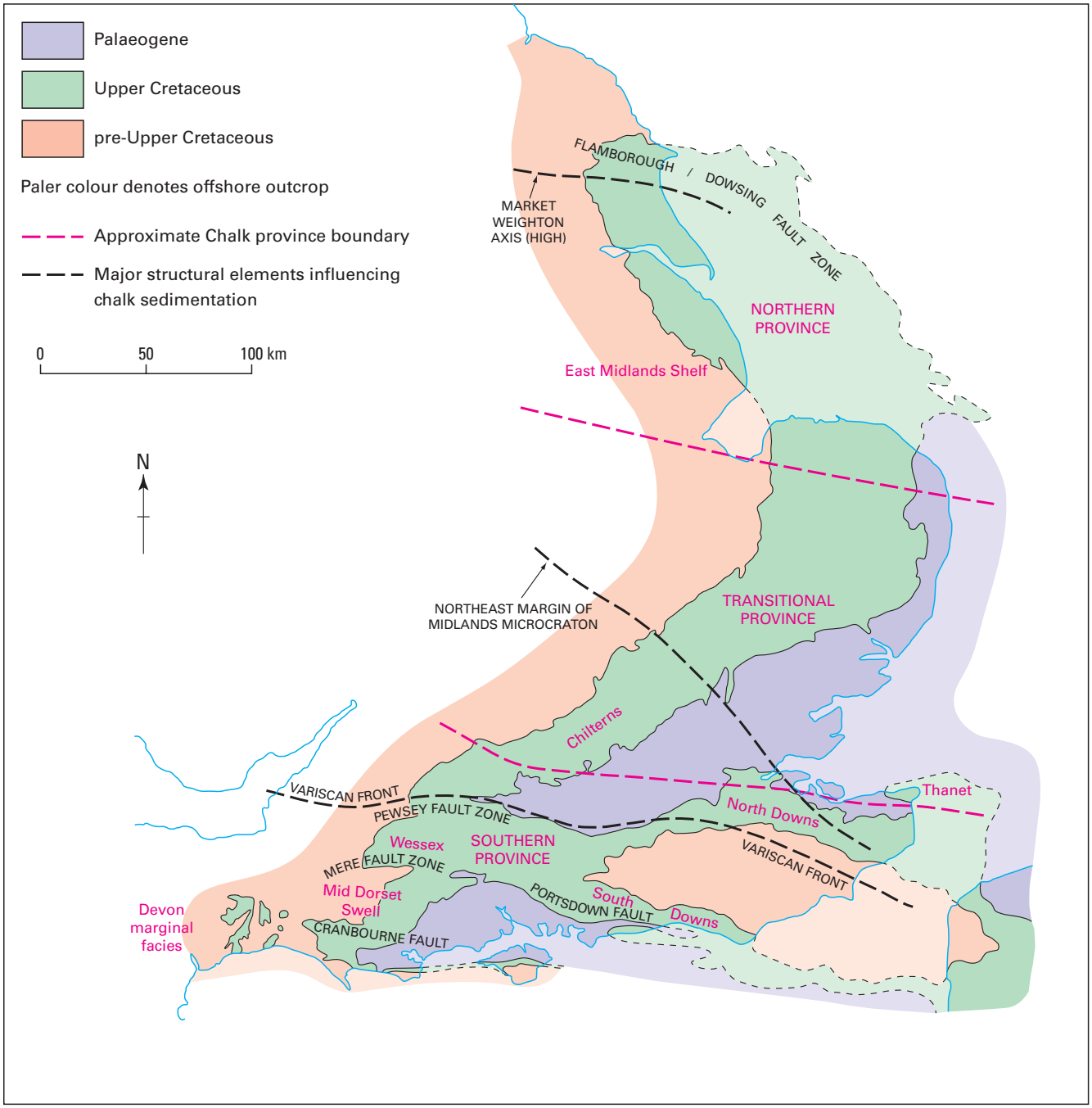


Figure 4 The Chalk Group provinces of England.

northwards, a major erosive event cutting into the Chalk Marl is found everywhere, and a condensed transgressive lag deposit (Totternhoe Stone), forming the lower part of the Grey Chalk, rests nonsequentially on various levels of the Chalk Marl. This event is equivalent to the transitional unit between the Chalk Marl and Grey Chalk, and marks the boundary between them. In the southern outcrop this event is represented by the Cast Bed (Price, 1877). It is used, together with the Totternhoe Stone farther north, to define the base of the newly formed Zig Zag Chalk Formation, thereby removing one of the long running arguments in Chalk correlation.

Robinson (1986) (Figure 5a, Column 8) introduced an entirely new lithostratigraphy for the North Downs by dividing the strata previously described as Lower Chalk into three formations. The lowest East Wear Bay Formation (equivalent to the Chalk Marl and lower part of the Grey Chalk) is characterised by its rhythmicity; the middle Abbot's Cliff Formation comprised massive slightly marly chalks, with the Plenus Marl Formation found at the top. He split the Abbot's Cliff Formation into two members, the Hay Cliff (equivalent to Jukes-Browne Bed VII) and the Capel-le-Ferne Member. Robinson makes no mention of the Cast Bed but it is evident from Kennedy (1969) and more succinctly in Gale (1989) that it occurs in Kent and would adequately divide the East Wear Bay Formation.

Bristow et al., (1995) (Figure 2, Column 4) created a new lithostratigraphy for the Lower Chalk in the Shaftesbury area of Dorset, and subsequently applied it, with modifications, across southern England (Bristow et al., 1997) (Figure 5a, Column 10). Originally they included the Glauconitic Marl (known locally as the Melbury Sandstone) in the Upper Greensand, and split the Lower Chalk into two members; the West Melbury Marly Chalk and the Zig-Zag Chalk members. Subsequently the

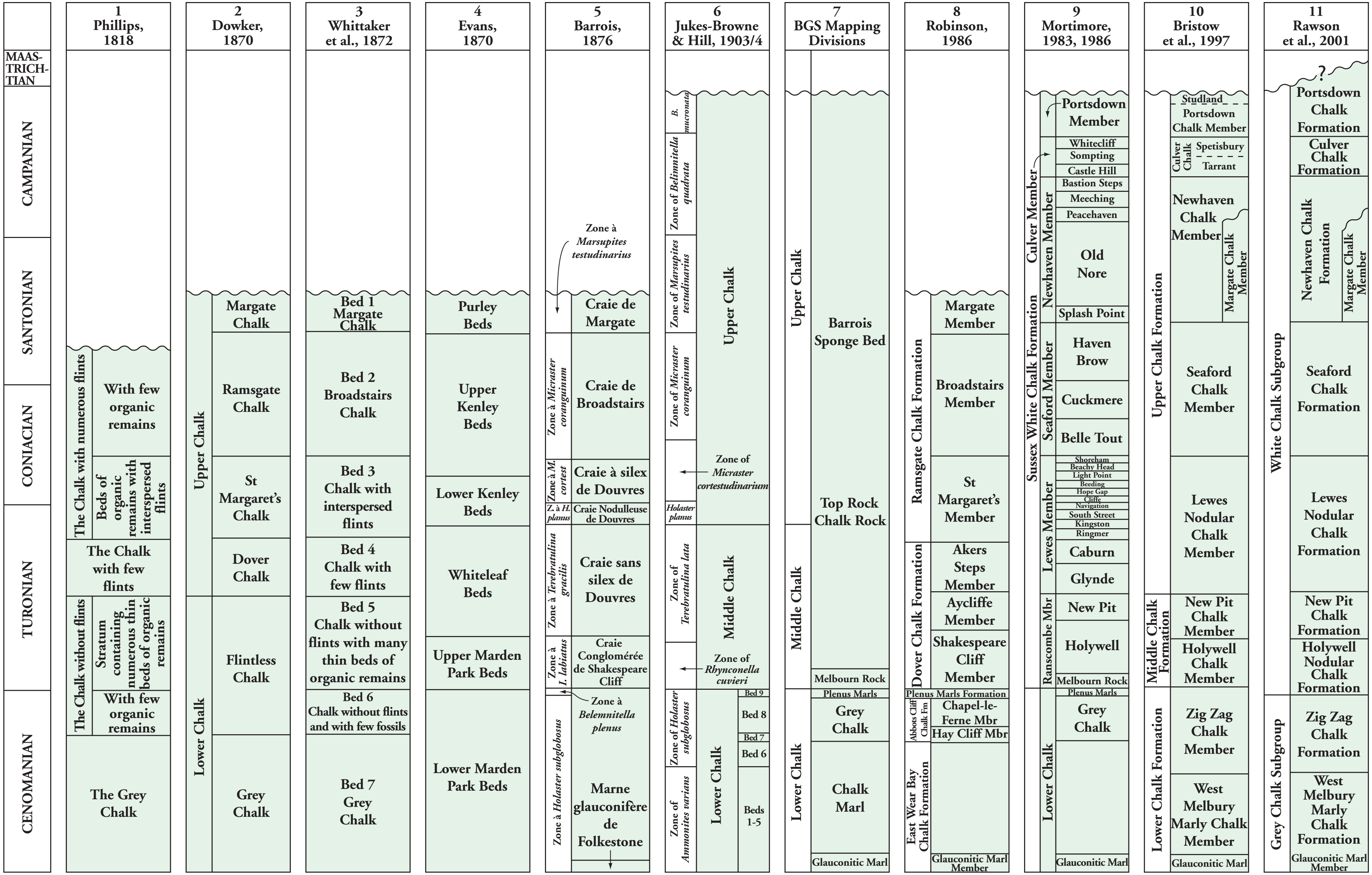


Figure 5a The development of the terminology in the Southern Province.

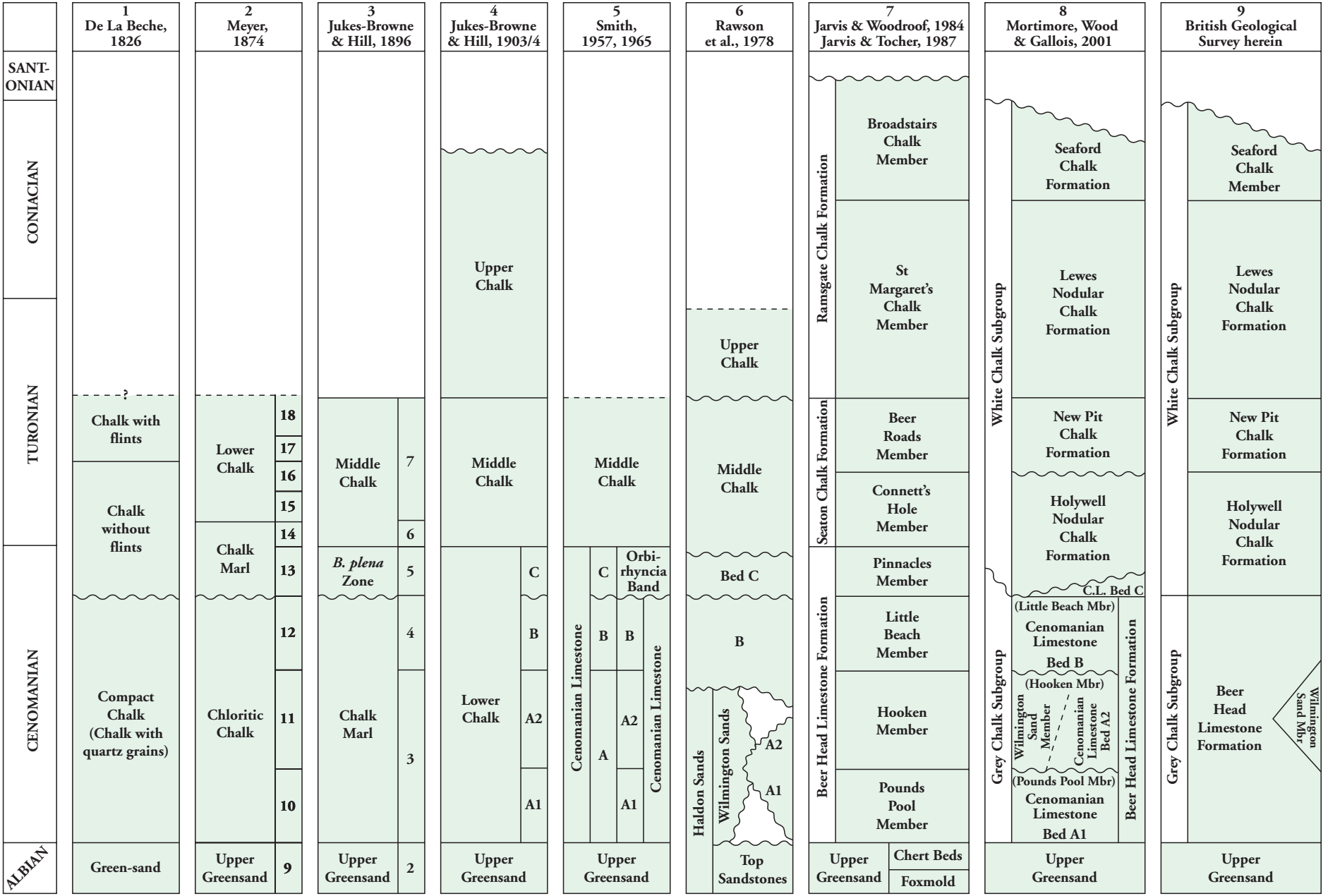


Figure 5b The development of the terminology in south-east Devon (Southern Province).

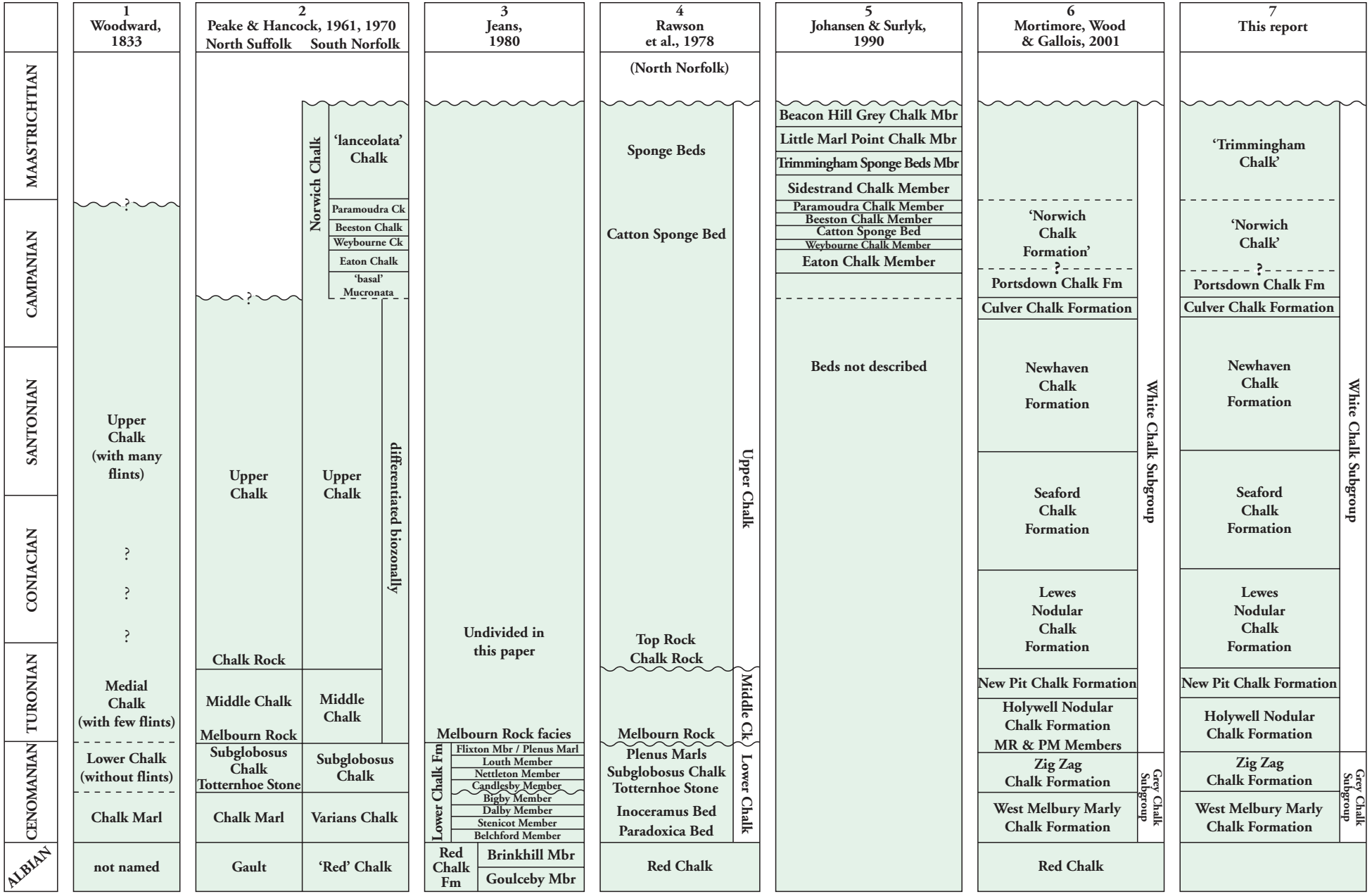


Figure 5c The development of the terminology in Norfolk (Transitional Province).

Glauconitic Marl/Melbury Sandstone was considered to be the basal bed of the West Melbury Marly Chalk Member because it was demonstrably of Cenomanian age and rested on a significant erosion surface. The boundary between the West Melbury and Zig Zag members, thus defined, was marked by a topographical slope change. This topographic feature coincides with the top of the thin Tenuis Limestone, where the full succession (rarely) exists, but is better defined by the base of the overlying Cast Bed (a lateral equivalent of the Totternhoe Stone). This boundary is some distance below the traditional Chalk Marl–Grey Chalk boundary as supported by Gale and Hancock (1999) but does represent a marked upward decrease in clay content. The Cast Bed is equivalent to bed C1 of Gale (1995).

In the most westerly outcrops of the Chalk Group in Devon (Jarvis and Woodroof, 1984) (Figure 5b, Column 7) the lithology of the Grey Chalk Subgroup changes and the new nomenclature at formation level is difficult to apply. The term Beer Head Limestone Formation (which is equivalent to the Grey Chalk Subgroup) will be used on the Sidmouth (326, 340) and westernmost Bridport (327) geological sheet areas to cover the succession below the Holywell Nodular Chalk Formation.

The **White Chalk Subgroup** in the Southern Province is defined as the succession from the base of the Plenus Marls Member of the Holywell Nodular Chalk Formation up to the youngest chalk beneath the unconformity at the base of the overlying Palaeogene or Quaternary deposits onshore south of the Wash (but see definition in the Northern Province). It comprises seven formations: The Holywell Nodular Chalk, the New Pit Chalk, the Lewes Nodular Chalk, the Seaford Chalk, the Newhaven Chalk, the Culver Chalk and the Portsdown Chalk. Historically this succession has been included within the Middle and Upper chalks. A short review of the development of the terminology for this subgroup is given below.

The first attempt to characterise any chalk units, which we might nowadays consider ‘members’, was by Whitaker (1865a) who described the Broadstairs Chalk and Margate Chalk as discrete lithological units with type localities. The ensuing decade saw a succession of papers naming chalk units after localities in Kent (Dowker, 1870) (Figure 5a, Column 2); (Whitaker et al., 1872) (Figure 5a, Column 3) and Surrey (Evans, 1870) (Figure 5a, Column 4). Evans named units have not been employed subsequently, but those of Whitaker and Dowker were used by Robinson (1986) (Figure 5a, Column 8) and Gale et al., (1987) and taken to have member status in a modern sense.

A monograph by Barrois (1876) (Figure 5a, Column 5) also pioneered the zonal stratigraphy of Hébert in Great Britain, and every time he used the term Chalk with a prefixed locality (i.e. Portsdown Chalk, Brighton Chalk, etc) he showed clearly which zone it belonged to. However, the units cannot be considered to be lithostratigraphical. The pattern of stratigraphical usage for the succeeding 100 years was set by Hill (1886) (Figure 5a, Column 6), who used the terms Lower, Middle and Upper Chalk, which were subdivided into Hébert's assemblage zones and retained other informal named lithological units.

Following the work of Rowe (1899 to1908) (see discussion in Gale and Cleevley, 1989) assemblage zones were used exclusively to subdivide chalk successions until the 1980s. However, lithological features and named beds were used continually as an aid to mapping, as with the case of the Middle-Upper Chalk boundary in the North Downs, and the feature-forming Chalk Rock and Melbourn Rock.

In addition to the work of the Survey, the first authors to introduce a lithostratigraphical scheme for the Chalk were Peake and Hancock (1961) (Figure 5c, Column 2) who placed Late Campanian to Maastrichtian chalks of north-east Norfolk within a series of informal members named after localities near Norwich and on the coast (e.g. Eaton, Weybourne and Beeston Chalks). Johansen and Surlyk (1990) (Figure 5c, Column 5) gave these units formal member status.

Jarvis and Woodroof (1984) (Figure 5b, Column 7) provided a lithostratigraphical subdivision of the Middle Chalk of Devon, which they placed within the Seaton Formation. They created two new members (Connet's Hole Chalk and Beer Roads Chalk). Bromley and Gale (1982) described the lithostratigraphy of the hardground complex called the Chalk Rock, which they took to be a formation.

Mortimore (1983, 1986) (Figure 5a, Column 9) published a new lithostratigraphy based on the South Downs for what he called the Sussex White Chalk Formation within which he created six new members with distinctive lithologies each with stratotypes in Sussex, Hampshire and the Isle of Wight (Ranscombe, Lewes, Seaford, Newhaven, Culver, and Portsdown). Each of these units was demonstrated in field meetings of the Geologists’ Association in 1977 and 1980.

This precedent and guiding ethos was used by Robinson (1986) (Figure 5a, Column 8) to create a separate lithostratigraphy for the North Downs. He in effect treated the Chalk as a group, and divided the White Chalk into two formations (Dover and Ramsgate) approximately equivalent to the Middle and Upper Chalk. These formations were divided into six members, three of which were taken from earlier researches (St Margaret's, Broadstairs and Margate members).

Mortimore (1987) suggested a correlation between his 1986 South Downs scheme and Robinson’s (1986) North Downs scheme, successfully applying his Sussex terminology to the Kent and Surrey succession. In reply, Robinson (1987) claimed that the succession in the North Downs differed from that in Sussex and required a different nomenclature. This has substantially not proved to be the case.

Gale et al., (1987) attempted to construct a compromise between the Mortimore and Robinson schemes, based on first usage priority of names, and incorporating some prezonal names employed by Robinson (1986) and many of the new ones of Mortimore (1986). This classification differed from the 1986 papers in one important respect — the concept of the term member. For both Robinson and Mortimore, members were recognisable along the entire outcrop, defined precisely by marker beds, and essentially synchronous. However in the Gale et al., (1987) scheme, some lithologically distinct members were recognised locally over a few square kilometres (e.g. Downend Member, Whitecliff Ledge Member) whilst others were recognised over hundreds (e.g. Chalk Rock Member). Gale et al., (1987) also introduced the term Studland Chalk for the unit of flinty, marl-free chalk that overlies the Portsdown Member of Mortimore but it has not proved mappable. The term Portsdown Chalk Formation is utilised herein to cover the highest outcropping chalk in Southern England. Mortimore (1988) provided a detailed criticism of the Gale et al., (1987) scheme. Subsequently, Rawson (1992) suggested a correlation between the schemes of Robinson (1986) and Mortimore (1986).

Mortimore and Pomerol (1987) extended the scheme developed in the South Downs (Mortimore 1986) to the Paris Basin, and traced the members and many marker beds across the Channel, through Normandy and Picardy to the Valley of the Yonne. It should be noted that other schemes of classification exist for the Chalk of the Pas de Calais (Robaszynski and Amedro, 1986) and Normandy coast (Juignet and Breton 1994) but that most recently the French state survey has shown an interest in applying the lithological framework defined herein across the Chalk of north-east France.

Gale (1996) provided a detailed account of the lithostratigraphy of the Turonian chalks of southern England, and introduced one new member, the Ballard Head Chalk, a replacement name for the Melbourn Rock of the south coast, sensu Mortimore (1986).

Following the introduction of the first detailed truly lithostratigraphical schemes for the Chalk of the Southern Province in 1986 the British Geological Survey (BGS) began to question the appropriateness of the traditional scheme. Thus, mapping of the western South Downs, east Hampshire and Wiltshire–Dorset areas by the BGS in the 1990s established a close correlation between units mappable across these areas with the scheme devised by Mortimore. A unified lithostratigraphy for the mapping of the Chalk was published (Bristow et al., 1997) (Figure 5a, Column 10) following a BGS meeting at Wallingford on the 9 June 1994. This scheme has been further modified by agreement at the Chalk Lithostratigraphy meeting held at BGS Keyworth in November 1999, resulting in the short letter published in the Geoscientist (Rawson et al., 2001) (Figure 5a, Column 11) and demonstrated more fully on the Geological Society's Web Site. The principal elements of that new stratigraphy are presented in Figure 2 and are described below (see Figure 5a, Column 10 and 5a, Column 11).

The following definitions cover the New Chalk Stratigraphy as promulgated in Rawson, Allen and Gale 2001 following the joint stratigraphical framework meeting held at BGS Keyworth in November 1999. As such they should be taken as the standard nomenclature in all future BGS publications in the Southern (including where possible the Transitional) Province of England. The lithostratigraphical units used on 1:50 000 geological maps and in descriptive memoirs for the Southern and Transitional provinces are set out in Table 2.

2.1 CHALK GROUP

Name

The term Chalk Group was introduced by Wood and Smith (1978) to cover all of the chalk in the Northern Province (as such it included the Hunstanton Formation). It had previously been used offshore by Rhys (1974) and by Robinson (1986) to cover the entirely Upper Cretaceous chalks in Kent. Bristow, Mortimore and Wood (1997) used the term to cover the chalks of the Southern Province as part of their new chalk nomenclature and this usage was agreed and published by Rawson, Allen and Gale (2001) following the stratigraphic meeting held at the BGS in 1999.

Type section

With the exception of well sections in the North Sea there is no single expanded and entire succession known for the whole group. The most complete onshore exposure is in the near vertically inclined cliff sections on the Isle of Wight where, under favourable conditions, the greater part of the known Southern Province sequence can be seen.

The sea cliffs of Sussex and Kent afford many of the individual formation stratotype sections for the Southern Province, whilst the sea cliffs and extensive inland exposures in Yorkshire and Lincolnshire provide the stratotypes for the constituent Northern Province formations.

Primary reference section

See notes above.

Table 2 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of the Southern and Transitional Provinces of England.

Name of Unit	Lexicon code	Map symbol
Beer Head Limestone Formation	None	None
Cambridge Greensand Member	CBG	CGS
Chalk Rock Member	CKR	CkR
Culver Chalk Formation	CUCK	CCk
Glauconitic Marl Member	GLML	GM
Grey Chalk Subgroup	GYCK	GyCk
Holywell Nodular Chalk Formation	HCK	HCk
Kensworth Nodular Chalk Member	KNCK	None
Lewes Nodular Chalk Formation	LECH	LeCk
Margate Chalk Member	MACK	MaCk
Melbourn Rock Member	MR	None
Melbury Sandstone Member	MYS	Mels
New Pit Chalk Formation	NPCH	NPCk
Newhaven Chalk Formation	NCK	NCk
Plenus Marls Member	PLMA	None
Seaford Chalk Formation	SECK	SCk
Spetisbury Chalk Member	SPCH	SpCk
Stockbridge Rock Member	STRK	STRK
Studland Chalk Member	STCK	StCk
Tarrant Chalk Member	TACH	TCk
Top Rock Bed	TRK	TRk
Totternhoe Stone Member	TTST	TtSt
West Melbury Marly Chalk Formation	WMCH	WMCk
White Chalk Subgroup	WHCK	WhCk
Zig Zag Chalk Formation	ZZCH	ZCk

Formal subdivisions

The group is formally divided into two subgroups, the Grey Chalk and White Chalk subgroups, and numerous formations throughout England with schemes developed for the Northern and Southern provinces. Well-known units used to divide the succession further are given member status. These units are defined herein.

Lithology

Chalk, with or without flint and discrete marl, sponge, calcarenite, phosphatic, hardground and fossil-rich beds.

Definition of upper boundary

Unconformable beneath the Palaeogene or Quaternary basal unconformity onshore in the UK. Conformable beneath Danian age Maureen Formation in parts of the North Sea. Elsewhere unconformable.

Definition of lower boundary

Generally unconformable (at a burrowed surface) on the underlying Lower Cretaceous strata (Upper Greensand and Gault formations in the Southern Province and on the Hunstanton Formation in the Northern Province). Oversteps onto older strata in limited basin marginal situations.

Thickness

The thickness of the whole group is variable depending on the degree of post-Cretaceous erosion and the relative development of its constituent formations. Onshore the thickest development is within the Hampshire/Sussex area of the Southern Province, where up to about 560 m of strata are preserved; the most chronostratigraphically complete succession is in Norfolk but it is thought to be only some 400 m thick there; within the Northern Province up to 530 m are preserved but the thickest succession is within the North Sea area where about 1000 to 1300 m are preserved.

Distribution

The group is known throughout the onshore outcrops in England and offshore in the Southern, Central and Northern North Sea areas.

Previous names

Known simply as the Chalk, or the Chalk Formation since the earliest writings it is perhaps the most readily identifiable geological unit and rock type in the world. The word chalk is derived from the Saxon cealc or German kalk and has been in use since the Middle Ages with Martin Lister (1684) frequently being credited with the first publication of the name. The use of the term Chalk Group was formally proposed by Wood and Smith (1978) in their classification of the 'Northern Province'; it was introduced to cover the Chalk of the North Sea by Rhys (1974) and is used by Robinson (1986) specifically to describe the whole of the Chalk of the North Downs. Group is implied by the use of the term formation to describe its constituent parts by Mortimore (1986). *The Correlation of Cretaceous Rocks of the British Isles* (Rawson et al., 1978) uses the term Chalk Formation and utilises the traditional terms Lower, Middle and Upper Chalk without recourse to a formal status suffix. Bristow, Mortimore and Wood (1997) used the term Chalk Group to encompass their Lower, Middle and Upper Chalk formations. It is equivalent to the Inner Hebrides Group in Scotland (see Section 4), the Hibernian Greensand and Ulster White Limestone groups taken together in Northern Ireland (see Section 5) and the Shetland Group in the Northern North Sea.

Parent

None

Age and biostratigraphy

Upper Cretaceous, Cenomanian to Maastrichtian.

References

Rawson, Allen and Gale, 2001; Wood and Smith, 1978; Rhys, 1974.

2.1.1 Grey Chalk Subgroup

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England.

Type section

None defined for the whole subgroup. Full succession visible under favourable conditions in the Isle of Wight and on the Kent coast around Folkestone in the Southern Province where the constituent formations have their type sections. Can be considered as defined by reference to the type sections of the Ferriby Chalk Formation in the Northern Province.

Primary reference section

The coastal section between Copt Point, Folkestone [TR 242 365] and Hay Cliff [TR 301 394] including Abbots Cliff path [TR 268 385] in the Southern Province as discussed in Robinson (1986).

Speeton Cliffs [TA 162 752 to TA 192 744] (Wright, 1968; Mitchell, 1995a) in the Northern Province.

Formal subdivisions

Divided in the Southern Province into the West Melbury Marly Chalk Formation and the Zig Zag Chalk Formation as defined herein. Is coextensive with the Ferriby Chalk Formation of the Northern Province.

Lithology

Clayey ('marly') chalk without flint. The lower part comprises limestone/marl 'couplets' equivalent to the West Melbury Marly Chalk Formation in the Southern Province. Upper part distinctly less 'marly' with notable calcarenite beds and is equivalent to the Zig Zag Chalk Formation of the Southern Province. The Ferriby Formation of the Northern Province is the lateral equivalent of the Grey Chalk Subgroup and comprises grey, soft, marly, flint-free chalk, typically weathering buff in exposures; locally includes pinkish bands; some harder, gritty, shell-debris-rich beds, and thin discrete marl seams.

Definition of upper boundary

Conformable at the highest bedding plane beneath the lowest bed of the Plenus Marls Member of the Holywell Nodular Chalk Formation in the Southern Province and the Welton Chalk Formation in the Northern Province. (Note that the Plenus Marls Member is now considered as part of the overlying subgroup thus providing a consistent datum throughout the Chalk Group of England and the North Sea).

Definition of lower boundary

Unconformable, set at the burrowed erosion surface marking the base of the Cenomanian. In the Southern Province this marks the distinct change from chalk-free to chalk-rich sediment. In the Northern Province the boundary is at an erosion surface between the Ferriby and Hunstanton formations.

Thickness

Variable, generally between 45 and 90 m in Southern Province. Is equivalent to the 30 m or so of the Ferriby Chalk Formation of the Northern Province.

Distribution

The subgroup is known throughout the onshore outcrops in England and offshore in the Southern, Central and Northern North Sea areas. In the Northern Province the term Ferriby Chalk Formation is analogous.

Previous names

Equivalent in part to the Lower Chalk (with the exception of the Plenus Marls Member) of the traditional scheme in the Southern and Northern provinces; to the Ferriby Chalk Formation of Woods and Smith (1978), and most of the Lower Chalk Formation of Bristow, Mortimore and Wood (1997). Equivalent to the Hydra or Swarte formations, respectively in the Central and Northern, North Sea Basins.

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to *Calycoceras guerangeri* zones.

References

Subgroup first defined herein, with the term only published in Rawson, Allen and Gale (2001).

2.1.1.1 West Melbury Marly Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. This term is essentially the same as the member defined in Bristow et al., (1997) (Figure 5a, Column 10).

Type section

Disused Melbury Quarry [ST 8753 2015] south of Shaftsbury as in Bristow, Mortimore and Wood (1997), but better defined and seen at the reference sections below.

Primary reference section

The three most significant reference sections are to be found in the cliff sections of the Kent and Sussex coasts and on the Isle of Wight. Copt Point [TR 242 365] to Hay Cliff [TR 301 394] (including Abbots Cliff and path [TR 268 385]), Folkestone to Dover, Kent; Southerham Grey Pit, Sussex [TQ 427 090]; Compton Bay, Isle of Wight [SZ 350 855]; Chinor [SU 754 994] in Oxfordshire.

Formal subdivision

Includes the equivalents of the Melbury Sandstone Member, Glauconitic Marl Member and the Cambridge Greensand Member at the base.

Lithology

Buff, grey and off-white, soft, marly chalk and hard grey limestone arranged in couplets.

Definition of upper boundary

Conformable in 'full' sequences at the erosional base of the overlying Cast Bed 'Member' (Bed C1 of Gale, 1995) of the Zig Zag Chalk Formation in the Southern Province and by the base of the Totternhoe Stone Member, its lateral equivalent, in the Transitional Province north of the Thames. This mid-Cenomanian erosional break marks the change from well-defined limestone marl couplets below to chalks with marls above and also the boundary between the 'B' and 'C' Chalk Marl couplets of Gale (1995). In full sequences the 'Tenuis Limestone' is the bed immediately beneath the mid-Cenomanian break.

Definition of lower boundary

Unconformable. Base marked by an erosion surface, frequently bored, at the base of the Glauconitic Marl Member (Southern Province), Melbury Sandstone Member (western Southern Province) or Cambridge Greensand Member (Transitional Province).

Thickness

In general between 15 and 25 m of these beds are preserved but they are absent over the Mid Dorset Swell (Drummond, 1970; Kennedy, 1970; Bristow et al., 1995) and thin over other syndepositional structural highs.

Distribution

Throughout the Southern Province and the Transitional Province of England. Is known to be absent or attenuated over structural highs. Most notably the Mid Dorset Swell.

Previous names

In part equivalent to the Chalk Marl of the traditional scheme. Formerly known as the West Melbury Marly Chalk Member as first proposed (Bristow, Mortimore and Wood, 1997) and upgraded to formation status in Rawson, Allen and Gale (2001). Equivalent to the lower part of the East Wear Bay Chalk Formation of Robinson (1986).

Parent

Grey Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to *Cunningtoniceras inerme* zones.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood 1997.

Glauconitic Marl Member

Name

Traditionally termed the Glauconitic Marl for example in Jukes-Browne and Hill (1903). By implication a member in Robinson (1986), and in Survey memoirs in Sussex e.g. Young and Lake (1988) and as defined herein.

Type section

East Wear Bay [TR 261 383], Kent.

Primary reference section

Isle of Wight: coastal section, Compton Bay.

Formal subdivision

None

Lithology

Calcareous glauconitic sand and glauconitic sandy silty chalk with phosphatic nodules.

Definition of upper boundary

Upward cessation of sand and/or abundant glauconitic grains (and phosphatic pebbles)(can occur as a rapid transition over 10 cm or less) into grey, sparsely glauconitic chalky marl or marly chalk, comprising the rest of the West Melbury Marly Chalk Formation.

Definition of lower boundary

Base of glauconite-rich sand or clay resting disconformably, at a strongly burrowed surface, on pale grey siltstones of the Upper Greensand (or grey mudstones of the Gault), which contain only a trace of glauconite at most. (Note: bioturbation may carry glauconitic sediment down into underlying formation).

Thickness

Between 2 and 4 m throughout much of Southern Province but may be only a few tenths of a metre elsewhere over synsedimentary structural highs. Up to 5 m in Kent and at Eastbourne, East Sussex.

Distribution

Known throughout much of the Southern Province in Kent, Surrey, Sussex, Hampshire and Berkshire.

Previous names

Chloritic Marl in older publications due to the misidentification of the glauconite. Laterally equivalent to the Cambridge Greensand of the Transitional Province; and the Melbury Sandstone Member in the western outcrops. Over the Mid Dorset Swell and other synsedimentary highs in the western area Kennedy (1970) uses the term 'Basement Bed' to describe the diachronous phosphatic and glauconite-rich basal unit of the Chalk whose age ranges up to the Upper Cenomanian.

Parent

West Melbury Marly Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* Zone, *Neostlingoceras carcitanense* Subzone. (Note: over synsedimentary highs such as the Mid Dorset Swell the age range may well included zones up to *Acanthoceras rhotomagense*).

References

Jukes-Browne and Hill, 1903; Kennedy, 1969; Robinson, 1986; Young and Lake, 1988; Lake, Young, Wood and Mortimore, 1987.

Melbury Sandstone Member

Name

Defined in Bristow (1989) where it was considered to be the highest unit within the Upper Greensand Formation and formerly known as the Cenomanian Sands, Passage Beds or Warminster Greensand. Regarded in recent BGS publications and herein as the lateral equivalent of the Glauconitic Marl Member.

Type section

Old quarry (now backfilled), 700 m at 276 degrees from Melbury Abbas church. Section recorded by Jukes-Browne and Hill (1900, 1903).

Primary reference section

See above

Formal subdivision

None

Lithology

Richly fossiliferous, glauconitic, fine-grained sand and weakly cemented sandstone.

Definition of upper boundary

The incoming of marl is taken as the basal bed of the overlying remainder of the West Melbury Marly Chalk Formation. This can frequently be a minor erosion surface.

Definition of lower boundary

Above the highest bed of chert of the Boyne Hollow Chert.

Thickness

Between 0 and 6 m (1.22 m at type locality).

Distribution

Known for Dorset and Wiltshire.

Previous names

Cenomanian Sands, Passage Beds, Warminster Greensand. Laterally equivalent to the Glauconitic Marl Member and the Cambridge Greensand Member. Formerly considered to be the highest member of the Upper Greensand Formation.

Parent

West Melbury Marly Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* Zone, *Neostlingoceras carcitanense* Subzone.

References

Bristow, 1989; Drummond, 1970; Kennedy, 1970; Jukes-Browne and Hill, 1900, 1903; White, 1923.

Bookham Conglomerate Bed

Name

The Bookham Conglomerate is defined in Bristow et al., (1995) where it was considered to pass laterally into the basal part of the Melbury Sandstone Member (which itself was considered therein to be the highest unit within the Upper Greensand Formation at that time).

Type section

Bookham Farm [ST 7065 0414]

Primary reference section

See above

Formal subdivision

None

Lithology

Clasts of very glauconitic shelly sandstone, up to cobble size, commonly with a phosphatic rind, together with phosphatised shells (bivalves and ammonites) in a matrix of sandy glauconitic chalk. The derived fauna is latest Albian; the indigenous fauna is early Cenomanian.

Definition of upper boundary

At the disconformable contact with phosphatic pebble bed at the base of the Zig Zag Chalk Formation or the West

Melbury Marly Chalk Formation (at the base of the Chalk Basement Bed of Kennedy, 1970).

Definition of lower boundary

Unconformable, locally strongly erosive boundary with underlying Shaftesbury Sandstone Member.

Thickness

Up to 1 m.

Distribution

Known from Dorset and Wiltshire over the Mid Dorset Swell.

Previous names

Passage Beds. Formerly considered to be the highest bed of the Upper Greensand Formation.

Parent

West Melbury Marly Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, lower and upper Cenomanian. Up to *Acanthoceras rhotomagense* zone.

References

Bristow et al., 1995; Drummond, 1970; Kennedy, 1970; Jukes-Browne and Hill, 1900, 1903; White, 1923; Smart, 1955.

Cambridge Greensand Member

Name

Known by a number of different names (see below) and given member status in Hancock (1972). Called the Cambridge Greensand on the Hitchin Sheet and formally regarded as a member equivalent to the Glauconitic Marl Member herein.

Type section

Established in brick pits as exposures become available. Currently Arlesey Brickpit. Active clay pit to west of mainline railway, west of Arlesey. Disused parts of pit used for landfill. Varies according to working.

Primary reference section

Arlesey Brickpit [TL 1879 3476] and Borehole TL 13SE 45 [TL 1887 3463].

Formal subdivision

None

Lithology

Glauconitic marl. Thin but distinctive condensed basement bed of pale greenish grey marl rich in phosphatic nodules (so called 'coprolites') at base. Much dark green glauconite as sand-sized grains, disseminated or concentrated in pods and layers giving a sandy texture and hence name 'greensand'. Rare erratic pebbles at base (Hawkes, 1943).

Definition of upper boundary

Rapid upward transition to 'Chalk Marl' or Lower Chalk lacking distinctive glauconite grains and nodule concentrations.

Definition of lower boundary

Disconformity. Sharp contact; commonly burrowed on underlying grey Gault Clay; glauconitic burrow infill to 0.3 below junction.

Thickness

Typically 0.1–1.0 m thick. Locally thicker developments infilling hollows on top of Gault. About 0.5–0.7 m at Arlesey Brickpit [TL 188 347] (Hopson, 1992).

Distribution

Known from the north Hertfordshire and Cambridgeshire area within the Transitional Province.

Previous names

Cambridge Bed, Chloritic Marl, Coprolite Bed, Glauconitic Marl, Nodule Bed, Phosphate Bed. Laterally equivalent to the Glauconitic Marl and Melbury Sandstone members.

Parent

West Melbury Marly Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* Zone, *Neostlingoceras carcitanense* Subzone.

References

Hancock, 1972; Edmonds and Dinham, 1965; Fitton, 1836; Hart, 1973; Hawkes, 1943; Hopson, 1992; Jukes-Browne, 1875; Rawson et al., 1978; Seeley, 1866.

2.1.1.2 Zig Zag Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. This term replaces that defined by Bristow et al. (1997) (Figure 5a, Column 10) and specifically excludes the Plenus Marls Member.

Type section

Bristow, Mortimore and Wood (1997) did not give a type section for the whole of the formation in Dorset but named it from the lower boundary reference section at the foot of Zig Zag Hill [ST 891 207] near Shaftsbury in Dorset. They referred to the sections in Kent and Sussex that can be considered as primary reference sections.

Primary reference section

The three most significant reference sections are to be found in the cliff sections of the Kent and Sussex coasts and on the Isle of Wight.
Copt Point [TR 242 365] to Hay Cliff [TR 301 394] (including Abbots Cliff and path [TR 268 385]), Folkestone To Dover, Kent; the Southerham Grey Pit and the adjacent Southerham Machine Bottom Pit, Sussex [TQ 427 090]; Compton Bay, Isle of Wight [SZ 350 855]; Chinor [SU 754 994] in Oxfordshire.

Formal subdivision

Includes the Totternhoe Stone Member and the laterally equivalent but informally named Cast Bed at its base.

Lithology

Mostly firm, pale grey to off-white blocky chalk with a lower part characterised by rhythmic alternations of marls and marly chalks with firm white chalk. Thin gritty, silty chalk beds act as markers in the sequence.

Definition of upper boundary

Conformable. The upper surface is redefined as the bedding plane beneath the lowest of the marls in the Plenus Marls Member in the overlying Holywell Nodular

Chalk Formation. (Note that the Plenus Marls Member is now considered as part of the overlying formation thus providing a consistent datum throughout the Chalk Group of England and the North Sea).

Definition of lower boundary

Conformable in full sequences. The lower boundary is placed at the erosional contact at the base of the 'Cast Bed' (Southern Province) or the Totternhoe Stone (Transitional Province) in southern England. The former is the direct equivalent of Bed C1 of Gale (1995). The formation oversteps onto older formations over the Mid Dorset Swell where the preceding West Melbury Marly Chalk Formation is absent. The basal unit here is termed the Cenomanian Basement Bed (Drummond, 1970).

Thickness

Generally in the range 35 to 50 m in the Southern Province with the most expanded successions (up to 75 m exceptionally) in the area of West Sussex, East Hampshire and the Isle of Wight. Thins markedly to the west and is at its least over the Mid Dorset Swell where as little as 10 m may be preserved.

Distribution

Throughout the Southern Province and the Transitional Province of England.

Previous names

Broadly equivalent to the 'Grey Chalk' of the traditional scheme. Most of the Zig Zag Chalk Member, (but without the Plenus Marls) of Bristow, Mortimore and Wood (1997). Equivalent to the upper part of the East Wear Bay Chalk Formation and the Abbots Cliff Chalk Formation of Robinson (1986).

Parent

Grey Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Acanthoceras rhotomagense* to *Calycoceras guerangeri* Zones.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

Totternhoe Stone Member

Name

The Totternhoe Stone of the traditional scheme and implicitly of member status within the Zig Zag Chalk Formation herein.

Type section

Totternhoe Stone Quarry [SP 980 222] west of Dunstable. Now forms the lowest part of the much larger encircling Lime Workings. Regarded as an expanded atypical sequence, almost 5 m thick (Aldiss, 1990).

Primary reference section

In the Hitchin district the Green Lagoon [TL 1978 3486], near Arlesey is in thin 'shelf' facies. The western face of the disused Chalk Quarry near the redeveloped Fairfield Hospital site shows an atypical 'channel' development (Hopson, 1992). Blue Lagoon [TL 1972 3444], Arlesey has about 1.0 m in typical shelf facies.

Formal subdivision

None. Informal quarrying terms used at the type site.

Lithology

A distinctly harder unit in the Grey Chalk Subgroup (Lower Chalk). Typically brownish-grey, fine-grained calcarenite. Has been described as 'sandy' because of coarse fossil fragments, not because of quartz sand grains. Thin to thickly bedded. Phosphatic in part with dark brown pellets a few millimetres across, up to nodules several centimetres across. Fossiliferous. Locally used as building stone.

Definition of upper boundary

Commonly indistinct conformable boundary with the overlying strata of the Zig Zag Chalk Formation (Lower Chalk, Grey Chalk unit). Upward reversion to softer, finer grained more typical chalk or marly chalk. May be difficult to locate, even in sections.

Definition of lower boundary

Commonly indistinct conformable boundary with the underlying West Melbury Marly Chalk Formation (Lower Chalk, Chalk Marl unit) but there may be an erosion surface with concentration of phosphatic pebbles in base of Totternhoe Stone above. May be difficult to locate, even in sections.

Thickness

Between 0.3 and 6.0 m in the Hitchin district. Typically 1–2 m thick but expanded sequences in synsedimentary channels may be up to 6 m thick.

Distribution

Known from Berkshire, Hertfordshire and Cambridgeshire where the Southern Province and Transitional Province overlap.

Previous names

Equivalent to the Cast Bed of the basinal successions in the Southern Province. Called the Chilton Stone on the Abingdon Sheet (253) (see entry under that title).

Parent

Zig Zag Chalk Formation (unit is the basal member of formation).

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Acanthoceras rhotomagense* Zone, *Turrilites costatus* Subzone.

References

Aldiss, 1990; Hancock, 1972; Hopson, 1992; Hopson, Aldiss and Smith, 1996; Jukes-Browne and Hill, 1887; Penning and Jukes-Browne, 1881; Rawson,et al., 1978; Whitaker, 1865b.

2.1.1.3 Beer Head Limestone Formation

Name

First proposed by Jarvis and Woodroof (1984) to replace the Cenomanian Limestone of Smith (1957, 1965) (Figure 5b, Column 5) but is redefined herein to exclude their Pinnacles Member which is equivalent to the Plenus Marls Member elsewhere. It was not mapped separately in south Devon but is traceable on coastal sections.

Type section

Hooken Cliffs, [SY 210 881 to 227 878], Devon.

Primary reference section

Beer Head [SY 227 879], and Wilmington Quarry [SY 209 997], Devon.

Formal subdivision

None herein but defined as comprising the Pounds Pool Sandy Limestone, Hooken Nodular Limestone and Little Beach Bioclastic Limestone members of the Beer Head Limestone Formation of Jarvis and Woodroof (1984).

Lithology

Complex thin sequence of bedded coarse calcareous sandstone, bioclastic limestone, calcarenite and shell-detrital limestone, with a distinct nodularity and well-developed hardgrounds. Glauconitic and phosphatic. Includes the Wilmington Sand Member in calcarenite facies.

Definition of upper boundary

Disconformable at the surface of the Humble Point Hardground with the Pinnacles Member (of Jarvis and Woodroof, 1984), which is the sub-Plenus Marls Member erosion surface.

Definition of lower boundary

Disconformable on the burrowed Small Cove Hardground of the Upper Greensand Formation.

Thickness

Up to 10.4 m at Hooken Cliffs.

Distribution

Confined to the area south of the Mid Dorset Swell in Dorset.

Previous names

Directly equivalent to the Chloritic Marl of Meyer (1874), the Chalk Marl of Jukes-Browne and Hill (1896) and the Cenomanian Limestone of Smith (1965). Correlates with the Pounds Pool Sandy Limestone, Hooken Nodular Limestone and Little Beach Bioclastic Limestone members of the Beer Head Limestone Formation of Jarvis and Woodroof (1984).

Parent

Grey Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to *Calycoceras geurangeri* zones.

References

Mortimore, Wood and Gallois, 2001.

2.1.2 White Chalk Subgroup

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England.

Type section

None defined for the whole subgroup. Full succession visible under favourable conditions in the Isle of Wight and on the Sussex and Kent coast in the Southern Province where the constituent formations have their type sections. Can be considered as defined by reference to the type sections of the constituent formations in the Northern Province.

Primary reference section

Isle of Wight and the coastal successions of Sussex (Mortimore, 1986) and Kent (Robinson, 1986) in the Southern Province. The numerous stratotypes for the constituent formations in the Northern Province (Wood and Smith, 1978).

Formal subdivisions

Divided in the Southern Province into the Holywell Nodular Chalk Formation, New Pit Chalk Formation, Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and the Portsdown Chalk Formation. In the Northern Province the subgroup comprises the Welton Chalk Formation, Burnham Chalk Formation, Flamborough Chalk Formation and the Rowe Chalk Formation.

Lithology

Chalk with flints. With discrete marl seams, nodular chalk, sponge-rich and flint seams throughout. Typology of flints and incidence of marl seams is important for correlation.

Definition of upper boundary

Unconformable beneath Palaeogene/Quaternary basal unconformity onshore in the UK. Conformable beneath Danian age Maureen Formation in parts of the North Sea. Elsewhere unconformable.

Definition of lower boundary

Conformable on the Grey Chalk Subgroup. Placed at the lowest bed in the Plenus Marls Member at the base of the Holywell Nodular Chalk Formation (Southern Province) and at the base of the same member in the Welton Chalk Formation (Northern Province). (Note that the Plenus Marls Member is now considered as part of this subgroup thus providing a consistent datum throughout the Chalk Group of England and the North Sea).

Thickness

Variable depending on degree of post-Cretaceous erosion and the relative development of its constituent formations. Onshore the thickest development is within the Hampshire/Sussex area of the Southern Province, where up to 470 to 515 m of strata are preserved; the most chronostratigraphically complete succession is in Norfolk but is thought there to be only some 350 m thick; within the Northern Province up to 500 m are preserved but the thickest succession is within the North Sea area where about 800 to 1100 m are preserved.

Distribution

The subgroup is known throughout the onshore outcrops in England and offshore in the Southern, Central and Northern North Sea areas.

Previous names

None directly equivalent, but the Sussex White Chalk Formation (with excludes the lowest Plenus Marls Member) of Mortimore (1986) is the closest match. Includes the Middle Chalk Formation and Upper Chalk Formation of Bristow, Mortimore and Wood (1997).

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian to Maastrichtian (onshore UK). *Metoicoceras geslinianum* to *Belemnitella mucronata* s.l. zones and into *Belemnella* spp. zones where the highest Campanian and Maastrichtian chalks are encountered. Up to basal Danian (basal Paleocene) in the North Sea Basin.

References

The subgroup is first defined herein, with the term only published in Rawson, Allen and Gale (2001).

2.1.2.1 Holywell Nodular Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. Replaces the mapping member of the same name proposed in Bristow, et al., (1997).

Type section

Beachy Head [TV 59 95] and Holywell [TV 603 973] section west of Eastbourne, Sussex.

Primary reference section

The Plenus Marls Member type site at Merstham [TQ 295 542] of Jefferies (1963) is now obscured. Robinson (1986) used Shakespeare Cliff [TR 307 398] in Kent as a reference section. The thickest onshore sequence is seen at Eastbourne adjacent to the Holywell Cafe [TV 602 967]. The Melbourn Rock was originally defined at Melbourn in Cambridgeshire where the type site is now poorly exposed in a car park beneath a building. A replacement type section is taken at Ashwell Quarry [TL 2687 3945] on the Biggleswade sheet (see Hopson et al., 1996). The Melbourn Rock Bed or Beds were defined by Mortimore (1986) and Robinson (1986) at Gun Gardens [TV 588 964] and Akers Steps [TR 297 394] respectively. Chinor [SU 754 994] in Oxfordshire.

Formal subdivision

Includes the Plenus Marls Member and the Melbourn Rock Member. Comprises a number of laterally persistent and named marl and flint beds in Mortimore (1986) that can be recognised outside the Sussex area over much of southern England.

Lithology

Generally hard nodular chalks with thin flaser marls and significant proportions of shell debris in part. Base marked by the interbedded coloured marl and chalk succession characteristic of the Plenus Marls Member (a term applicable in both the Southern and Northern Provinces). The Melbourn Rock Member above the base can be distinguished by its lack of shell material.

Definition of upper boundary

Conformable. Taken at the Gun Gardens Main Marl in the expanded sequences of the Southern Province and at the highest shell detrital bed in mapping terms.

Definition of lower boundary

Conformable. Base of the formation taken at the bedding plane immediately below the lower marl bed in the Plenus Marls Member. (Note that the Plenus Marls Member is now considered as part of this formation thus providing a consistent datum throughout the Chalk Group of England and the North Sea).

Thickness

In thicker successions this formation is generally 25 to 35 m thick. It thins rapidly into the Transitional Province of the North Downs, Berkshire Downs and the Chilterns (10 to 15 m) and is almost absent in the south-west of Dorset and in Devon.

Distribution

Known throughout the Southern Province, within the Chilterns and northward into East Anglia in the Transitional Province.

Previous names

Previously known as the Holywell Nodular Chalk Member of Bristow, Mortimore and Wood (1997), under which name it did not include the Plenus Marls. Equivalent to the Plenus Marl Beds, Lower and Middle Holywell Beds of Mortimore (1986); and the Plenus Marls Formation and lower part of the Shakespeare Cliff Member of the Dover Chalk Formation (Robinson, 1996). Includes the Melbourn Rock (Ballard Head Member of Gale, 1996). The name, as applied erroneously by Shephard-Thorn, 1988, referred to the whole of the condensed succession representing the Holywell Nodular Chalk Formation in East Kent.

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Cenomanian (uppermost) to Turonian. *Metoicoceras geslinianum* to *Mytiloides* spp. zones (the inferred top of the *Mammites nodosiodes* Zone).

References

Mortimore, 1986; Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

Plenus Marls Member

Name

Traditionally known as the Plenus Marls and defined by Jefferies (1963). Defined herein at member level marking the basal unit of the Holywell Nodular Chalk Formation.

Type section

Merstham Greystone Limeworks in Surrey [SU 295 542].

Primary reference section

Numerous throughout Southern and Northern Province see Jefferies (1963).

Formal subdivision

None herein but finely divided into eight beds of widespread geographical distribution by Jefferies (1963).

Lithology

Interbedded coloured marl and chalk.

Definition of upper boundary

Conformable at the bedding plane above the highest marl below the hard nodular limestone of the Melbourn Rock Member.

Definition of lower boundary

Conformable beneath the lowest marl on the underlying Zig Zag Chalk Formation. Sequence constitutes the lowest member of the Holywell Nodular Chalk Formation and the White Chalk Subgroup (see also the definition for the Northern Province).

Thickness

Usually in the range 1 to 1.5 m but known to be up to 3.0 m at the Holywell Cafe cliff section in Eastbourne.

Distribution

Widespread within the Southern, Transitional and Northern provinces (see additional entry for Northern Province) and offshore in the North Sea area. Forms the most characteristic downhole geophysical signature in the whole of the Chalk Group.

Previous names

Plenus Subzone in various Survey publications; Belemnite Marls.

Parent

Holywell Nodular Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Metoicoceras geslinianum* Zone.

References

Jefferies, 1963.

Melbourn Rock Member

Name

Recognition of the Melbourn Rock in the Cambridgeshire and Chiltern areas formed the basis on which the traditional tripartite scheme for the Chalk of southern England was erected by the Geological Survey (Jukes-Browne and Hill, 1903). It is herein regarded as of member status within the lower part of the Holywell Nodular Chalk Formation.

Type section

Named after Melbourn, in Cambridgeshire where two pits are described. The Melbourn Lime-kiln Pit and a second 'a quarter of a mile distant' both at the southern end of Melbourn. The type site is in a car park beneath a modern industrial building developed in the old (?) lime-kiln pit and is now in poor condition and the full sequence cannot be seen. A substitute type section and essentially the new stratotype is described in the Hitchin memoir (p. 47) at Ashwell [TL 2697 3945] where the full sequence from the Plenus Marls to well above the Melbourn Rock can be seen in a clean section.

Primary reference section

Numerous throughout the Southern and Transitional Province. Chinor in Oxfordshire, Folkestone–Dover in Kent, Eastbourne–Beachy Head in Sussex, Compton Bay on the Isle of Wight.

Formal subdivision

None

Lithology

Hard to very hard off-white, blocky fractured chalk with numerous nodular chalk beds and thin anastomosing marls.

Definition of upper boundary

Conformable but difficult to place in the Transitional Province where it is usually considered to be at a horizon of less hard flaggy chalks with significant anastomosing marls. This is probably equivalent to the Meads Marls succession of the Southern Province and Mortimore (1986) places the boundary at the Meads Marl 1 in Sussex.

Definition of lower boundary

Conformable on the highest marl seam of the Plenus Marls Member. This is the Foyle Marl of Mortimore (1986).

Thickness

About 3 m in the classic Chiltern area but noted to be between 2 and 7 m in the Hitchin Memoir (Hopson et al., 1996) and a range of 2.7 to 4 m is given in Mortimore (1986).

Distribution

Known throughout the Southern and Transitional provinces and forms the most readily identifiable geomorphological features in unexposed ground.

Previous names

Melbourn Rock as used in many BGS publications and external papers. Equivalent to part of the Grit Bed of Price (1877).

Parent

Holywell Nodular Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian to Turonian. *Metoicoceras geslinianum*, *Neocardioceras juddi* and basal *Mytiloides* spp. zones.

References

Hill and Jukes-Browne, 1886; Hill, 1886.

2.1.2.2 New Pit Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. Replaces the mapping member of the same name proposed in Bristow, et al., (1997).

Type section

Gun Gardens [TV 588 964] and Beachy Head [TV 576 953] sections in Sussex.

Primary reference section

Akers Steps [TR 297 394], Kent; Compton Bay [SZ 350 855].

Formal subdivisions

None herein but contains a number of laterally persistent and named marl and flint beds in Mortimore (1986) which can be recognised outside the Sussex area over much of southern England.

Lithology

Principally blocky, white firm to moderately hard chalk with numerous marls or paired marl seams. Flint occurs sporadically in the upper part in the deeper basin areas of the Southern Province. In some localities flint, in seams, occurs to the base of the formation most notably over structural highs, towards the margins of the outcrop and within the Transitional Province.

Definition of upper boundary

Conformable at the base of Glynde Marl 1 in Sussex, but one of the higher marls elsewhere although invariably in the interval Glynde Marls to Southerham Marls in the Southern Province. The mapping boundary is placed at the appearance of nodular chalks and significant flint development within that range of marls. In the Transitional Province the formation expands in response to the later inception of nodularity and hardground development (characteristic of the Lewes Nodular Chalk Formation) such that the upper boundary is diachronous here and placed below the 'Chalk Rock Member' at the Reed Marl (the lateral equivalent of the Bridgewick Marls of the Southern Province).

Definition of lower boundary

Conformable at the bedding plane immediately below the Gun Gardens Main Marl (the Lulworth Marl of Gale, 1996) in the standard Sussex succession. The mapping boundary is placed at the highest shell-detrital chalk and at the incoming of sporadic flints. In the Transitional Province the top of these shell-detrital chalks is at the Odsey Marl (See Hopson et al., 1996).

Thickness

Typically between 35 and 50 m but is as little as 10 to 25 m metres thick in Wiltshire, north Hampshire and Berkshire over synsedimentary structural highs. The formation expands in the Transitional Province where it is thought to be up to 75 to 80 m thick.

Distribution

Known throughout the Southern Province, within the Chilterns and northward into East Anglia in the Transitional Province.

Previous names

Known as the New Pit Chalk Member prior to Rawson et al. (2001). Also the upper and thicker part of the traditional Middle Chalk. Equivalent to the Upper Holywell Beds and New Pit Beds of the Ranscombe Chalk Member (Mortimore and Pomerol, 1996); and the upper part of the Shakespeare Cliff Member and Aycliff Member of the Dover Chalk Formation (Robinson, 1986).

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Turonian. The greater part of the *Terebratulina lata* Zone.

References

Mortimore, 1986; Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

2.1.2.3 Lewes Nodular Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. Replaces the mapping member of the same name proposed in Bristow, et al. (1997). The term Lewes Nodular and Flinty Chalk Member was used by Mortimore (1987) as part of his Sussex White Chalk Formation and adapted to Lewes Nodular Chalk Member within the Upper Chalk Formation by Bristow, Mortimore and Wood (1997).

Type section

The type sites for the Lewes Chalk as defined by Mortimore (1986) are at the Caburn Pit [TQ 447 089], Navigation Pit [TQ 426 099] and on the coast between Beachy Head [TV 576 953] and Light Point [TV 566 954], all in Sussex.

Primary reference section

Compton Bay [SZ 350 855] and Whitecliff Bay [SZ 638 854] on the Isle of Wight; White Nothe [SY 764 813] in Dorset; Akers Steps [TR 298 394] and Langdon Stairs [TR 341 422] near Dover, Kent; the Aston Rowant (Stokenchurch) M40 cutting [SU 728 965 to 740 965] Oxfordshire; Kensworth Chalk Pit [TL 015 197] in Bedfordshire.

Formal subdivision

Includes the Chalk Rock Member, the Kensworth Nodular Chalk Member and the Top Rock Bed. Includes a number of laterally persistent and named marl, hardground and flint beds in Mortimore (1986) that can be recognised outside the Sussex area over much of southern England.

Lithology

Composed of hard to very hard nodular chalks and hardgrounds (which resist scratching by finger-nail) with interbedded soft to medium hard chalks (some grainy) and marls; some griotte chalks. The softer chalks become more abundant towards the top. Nodular chalks are typically lumpy and iron-stained (usually marking sponges). Brash is rough and flaggy or rubbly, and tends to be dirty. First regular seams of nodular flint, some large, commence near the base and continue throughout.

Definition of upper boundary

Conformable at the Shoreham Marl 2 which is equivalent to the East Cliff Marl 2 in Kent and also identified at the Anstey Quarry [TL 395 329] south of Royston, in the Transitional Province. In the field, this is the most difficult boundary to place precisely because of the gradual upward transition in predominant lithology, with interbeds of hard chalk in soft chalk and vice versa. The most positive criterion is the incoming of abundant thick-shelled inoceramid debris (*Platyceramus*) in soft chalks, although this may not be applicable everywhere. The presence of a susseccion containing carious flints within the low Seaford Chalk and high Lewes Chalk is a helpful field indicator of the boundary.

Definition of lower boundary

Conformable at the base of Glynde Marl 1 in Sussex, but one of the higher marls elsewhere although invariably in the interval Glynde Marls to Southerham Marls in the Southern Province. The mapping boundary is placed at the appearance of nodular chalks and significant flint development within that range of marls.

In the Transitional Province the formation is condensed in response to the later inception of nodularity and hardground development such that the lower boundary is diachronous here and placed below the 'Chalk Rock Member' at the Reed Marl (the lateral equivalent of the Bridgewick Marls of the Southern Province).

Thickness

The formation is thickest in the basinal successions of the Southern Province in east Hampshire and Sussex where it attains c. 35 to 60 m in the east and up to 80 m in west. The formation thins towards the margins of the outcrop and over synsedimentary structural highs.

Distribution

Known throughout the Southern Province, within the Chilterns and northward into East Anglia in the Transitional Province.

Previous names

Lewes Nodular and Flinty Chalk Member of Mortimore (1986) in Sussex and the Lewes Nodular Chalk Member (Bristow et al., 1997). Equivalent to the Akers Steps Member of the Dover Chalk Formation and the St Margarets Member of the Ramsgate Chalk Formation of Robinson (1986) in Kent. Forms the lowest part of the traditional Upper Chalk.

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Turonian to Coniacian. Top *Terebratulina lata*, *Sternotaxis plana* (now *Plesiocorys plana*) and *Micraster cortestudinarium* zones.

References

Mortimore, 1986; Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

Chalk Rock Member

Name

Described as the Chalk Rock in the traditional scheme as exemplified in Jukes-Browne and Hill (1904). The term Chalk Rock Formation was adopted in Bromley and Gale (1982) and later as a member in Gale, Wood and Bromley (1987). Defined herein as a member within the Lewes Nodular Chalk Formation.

Type section

Ogbourne Maizey. Old farm west of Ogbourne Maizey, 3 km north of Marlborough, Wiltshire.

Primary reference section

Noted at 55 sites throughout the 'Transitional' and Southern Provinces in Bromley and Gale (1982).

Formal subdivision

None herein but is divided into a number of named hardgrounds (of bed status) in Bromley and Gale (1982).

Lithology

Very hard chalk and chalkstone, some nodular, including mineralised hardground surfaces, and marl seams.

Definition of upper boundary

Where the Hitch Wood Hardground is developed the boundary is placed at the flint nodule horizon that marks the base of the overlying nodular chalk unit. In other areas, at the Pewsey Hill Hardground or the Ogbourne Hardground.

Definition of lower boundary

The diffuse lower limit of cementation of the lowest bed of chalkstone at this level.

Thickness

Between 4 and 5 m where fully developed.

Distribution

Known throughout the Southern Province and in the Chiltern area of the Transitional Province.

Previous names

Chalk Rock (CkR). Chalk Rock Formation.

Note 1

Although Bromley and Gale's (1982) definition of the Chalk Rock is accepted, it is BGS practice to include the unit in the Upper Chalk of the traditional scheme and as a constituent part of the Lewes Nodular Chalk Formation in the new scheme. Thus the Chalk Rock is reduced in rank from formation (Bromley and Gale, 1982) to member.

Note 2

Gale, Wood and Bromley (1987) treat the Chalk Rock as a member of the 'White Chalk Formation' (= Middle and Upper Chalk of BGS). Equivalent to part of the Kingston Beds of Mortimore (1986) and part of the St Margarets Member of Robinson (1986).

Parent

Lewes Nodular Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Turonian. *Sternotaxis plana* (now *Plesiocorys plana*) Zone.

References

Whitaker, 1861; Bromley and Gale, 1982; Jukes-Browne and Hill, 1904; Gale, Wood and Bromley, 1987.

Kensworth Nodular Chalk Member

Name

First used and defined in the Hitchin Memoir (Hopson, Aldiss and Smith, 1996)

Type section

Kensworth Chalk Quarry [TL 017 197], near Dunstable, Bedfordshire.

Primary reference section

Reed Chalk Pit [TL 3595 3704], south of Royston, Hertfordshire.

Formal subdivision

Includes the Top Rock Bed

Lithology

Very hard nodular chalk and chalkstone, including mineralised hardground surfaces.

Definition of upper boundary

Conformable at the top of a succession of obviously indurated chalks within the Lewes Nodular Chalk Formation overlying the Chalk Rock Member. Note that this does not necessarily coincide with the top of the Top Rock Bed.

Definition of lower boundary

Conformable at the top of the Chalk Rock Member above the flint nodule horizon marking the top of the Hitchwood Hardground.

Thickness

About 2.5 to 4 m in Hitchin and Leighton Buzzard districts.

Distribution

Known within the Leighton Buzzard and Hitchin areas of the Chilterns.

Previous names

None

Parent

Lewes Nodular Chalk Formation.

Age and biostratigraphy

Upper Cretaceous Turonian and Coniacian. *Sternotaxis plana* (now *Plesiocorys plana*), *Micraster cortestudinarium* zones.

References

Hopson, Aldiss and Smith, 1996; Shephard-Thorn, Moorlock, Cox, Allsop and Wood, 1994.

Top Rock Bed

Name

The name was first used by Penning and Jukes-Browne (1881) to describe a distinctive bed(s) of hardground and nodular chalk development at a distinctly higher stratigraphical level than the Chalk Rock.

Type section

Reed Pit [TL 3595 3704] near Royston in Cambridgeshire.

Primary reference section

Kensworth [TL 017 197] (Leighton Buzzard); Hitch Wood Hill End [TL 1973 2398] (Hitchin).

Formal subdivision

None

Lithology

Hard cream limestone with scattered brownish phosphatic nodules commonly green-coated at the top. Mineralised hardground or chalkstone bed.

Definition of upper boundary

Conformable at the hardground surface marked by the change from mineralised hard chalkstone to soft white smooth chalk.

Definition of lower boundary

Conformable within the Kensworth Nodular Chalk Member at an indistinct boundary marking a significant increase in nodularity between 2 and 3 m above the uppermost hardground of the Chalk Rock Member.

Thickness

From 0.8 to 1.0 m in Cambridgeshire. And from 0.3 m to 1.0 m in the Chilterns to where it is essentially confined.

Distribution

The Chilterns within Hertfordshire and possibly Buckinghamshire.

Previous names

Forms part of the Kensworth Nodular Chalk Member.

Parent

Lewes Nodular Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Turonian to Coniacian. *Micraster cortestudinarium* Zone.

References

Penning and Jukes-Browne, 1881; Brighton, 1928; Worssam and Taylor, 1969.

2.1.2.4 Seaford Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. The term Seaford Chalk Member was used by Mortimore (1987) as part of his Sussex White Chalk Formation and adopted as Seaford Chalk Member within the Upper Chalk Formation by Bristow, Mortimore and Wood (1997).

Type section

Seaford Head [TV 496 976] in Sussex.

Primary reference section

Light Point, through Birling Gap [TV 553 959] to the Seven Sisters and numerous other sites in Sussex; Whitecliff Bay [SZ 638 854] on the Isle of Wight; in a number of discontinuous sections between Hope Point [TR 379 463] and White Ness [TR 397 710] in Kent; Ballard Point [SZ 048 813] and White Nothe [SY 764 813] in Dorset.

Formal subdivision

Includes the Stockbridge Rock Member in the Hampshire Downs area. Includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams. Hardgrounds and thin marls known from the lowest beds.

Definition of upper boundary

Conformable at the Buckle Marl 1 in the Sussex succession. The incoming of common *Zoophycos* flints and the presence of the zonal *Uintacrinus socialis* crinoid at the base of the Newhaven Chalk Formation are useful indicators in the field.

Definition of lower boundary

Conformable at the base of Shoreham Marl 2 in Sussex that marks the change from regularly spaced nodular and grainy chalk beds of the upper Lewes Nodular Chalk Formation to smooth white chalks. This marl is equivalent to the East Cliff Marl 2 in Kent and which is also identified at the Anstey Quarry [TL 395 329] south of Royston, in the Transitional Province.

In the field, this is the most difficult boundary to place precisely as it falls in the sequence where the predominance of interbeds of hard chalk reduces in favour of soft chalk. The most positive criterion is the incoming of abundant thick-shelled inoceramid debris (*Platyceramus*) in soft chalks, although this may not be applicable everywhere. The presence of a succession containing carious flints within the low Seaford Chalk and high Lewes Chalk is a helpful field indicator of the boundary. Geomorphologically the formation characteristically forms long even dipslope crests.

Thickness

Generally in the range 50 to 80 m in the basinal successions of Sussex and Hampshire within the Southern Province. Equivalent beds in Kent are in the range 55 to

60 m. Over considerable areas of southern England the thickness of this unit is limited by erosion beneath the sub-Palaeogene unconformity.

Distribution

Known throughout the Southern Province, within the Chilterns and northward into East Anglia in the Transitional Province.

Previous names

Seaford Member of Mortimore (1986) and as adapted in Bristow et al., (1997). Broadly equivalent to the Broadstairs Member of the Ramsgate Chalk Formation of Robinson (1986) in Kent.

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Coniacian to Santonian. *Micraster coranguinum* Zone.

References

Mortimore, 1986; Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

Stockbridge Rock Member

Name

Described in the Winchester Sheet Explanation (Booth, 2002) and Farrant (2001).

Type section

Type area only in the Stockbridge district. Ongoing research in progress but the unit is identified from its characteristics porcellanous limestone brash in the field.

Primary reference section

Poor exposure in a silage pit at Beech Farm, Nether Wallop [SU 2845 3537].

Formal subdivision

None

Lithology

Very hard, locally porcellanous, creamy white chalk, grainy in part with abundant sponge spicules.

Definition of upper boundary

Conformable at the top of the uppermost bed of very hard chalk.

Definition of lower boundary

Conformable at the change from soft white smooth chalk to very hard chalk. Placed within the higher part of the Seaford Chalk Formation.

Thickness

Not known in detail but estimated to be 2 to 3 m. Member may be a number of such beds of hard chalk between 5 and 10 m below the mapped base of the Newhaven Chalk Formation.

Distribution

Occurs in the high part of the Seaford Chalk Formation in the Winchester, Stockbridge area of Hampshire and westwards within the Bourne and Avon valleys near Salisbury. Central Hampshire and Wiltshire in the Southern Province. May extend northwards into Berkshire.

Previous names

Informally described as the Winchester Hardground. May be the lateral equivalent of the Whitway Rock. The member occurs at about the level of the Barrois Sponge Bed and the Clandon Hardground of the North Kent succession.

Parent

Seaford Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Santonian (?). *Micraster coranguinum* zone.

References

Farrant, 1999, 2000.

2.1.2.5 Newhaven Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. The term Newhaven Chalk Member was used by Mortimore (1987) as part of his Sussex White Chalk Formation and adopted as the Newhaven Chalk Member within the Upper Chalk Formation by Bristow, Mortimore and Wood (1997).

Type section

Seaford Head [TV 496 976] in Sussex.

Primary reference section

Newhaven [TV 446 999] to Brighton [TQ 338 033] cliff's Sussex; Paulsgrove Pit [SU 635 065] on Portsdown; Whitecliff Bay [SZ 638 854] on the Isle of Wight; White Ness [TR 397 710] to Foreness Point [TR 383 717] and Margate [TR 354 714] on the Thanet Coast in Kent; Ballard Point [SZ 048 813] and White Nothe [SY 764 813] in Dorset.

Formal subdivision

Informally includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Composed of soft to medium hard, smooth white chalks with numerous marl seams and flint bands, including abundant *Zoophycos* flints (notably at levels near the base). The formation is known to contain distinct phosphatic chalks of limited lateral extent. Equivalent beds, the Margate Chalk of north Kent, are marl-free and contain little flint.

Definition of upper boundary

Placed at the Castle Hill Marl 2 in the type locality at Seaford Head, Sussex where there is some evidence of a reduction in marl thickness over a structural high. In expanded trough areas a higher set of marls, the Pepper Box Marls, are well developed and the boundary is taken at this level.

Definition of lower boundary

Conformable at the Buckle Marl 1 in the Sussex succession. The incoming of common *Zoophycos* flints and the presence of the zonal *Uintacrinus socialis* crinoid

at the base of the Newhaven Chalk Formation are useful indicators in the field.

Thickness

From 45 to 75 m in the basinal sequences of the Southern Province. Limited by sub-Palaeogene erosion over large areas of southern Britain.

Distribution

Known throughout the Southern Province northward to the Pewsey/Kingsclere structure and as limited outliers north of this structure. Its presence within the Chilterns and northward into East Anglia in the Transitional Province is not well known.

Previous names

Newhaven Chalk Member of Mortimore (1986) and as adopted in Bristow et al. (1997). Broadly equivalent to the Margate Chalk Member of the Ramsgate Chalk Formation of Robinson (1986) in Kent.

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Santonian to Campanian. *Uintacrinus socialis*, *Marsupites testudinarius*, *Uintacrinus anglicus* and *Offaster pilula* Zones.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

Margate Chalk Member

Name

Defined in Robinson (1996). Herein taken as the modified classification in Bristow, Mortimore and Wood (1997).

Type section

North Foreland [TR 398705] to Foreness Point [TR 385 717] and Palm Bay [TR 380 715] on the Isle of Thanet, north Kent.

Primary reference section

As above

Formal subdivision

None herein. Informally includes a number of laterally persistent flint and marl beds named in Robinson (1986) which can be traced outside Kent in the Southern and Transitional provinces where they are correlated with the named beds of Mortimore (1986)

Lithology

Marl-free smooth white chalk with little flint, weakly developed indurated iron-stained sponge beds.

Definition of upper boundary

Limited by sub-Palaeogene erosion surface in the Isle of Thanet.

Definition of lower boundary

Conformable at the surface immediately above the Barrois Sponge Bed in Thanet (Robinson, 1986).

Thickness

Up to 24 m in the North Foreland to Foreness Point and Palm Bay sections on the Isle of Thanet in north Kent.

Distribution

Confined to the Thanet area of Kent and possibly northwards into Essex and southern East Anglia.

Previous names

Margate Member of the Ramsgate Chalk Formation of Robinson (1986). The 'Margate Chalk' of Whitaker (1865a, 1872). Margate Chalk Formation definition in BGS lexicon. Lateral equivalent of the greater part of the Newhaven Chalk Formation. The lateral extent of this member is not known and may well be confined to the Thanet area although there are indications of this lithology in Essex.

Parent

Newhaven Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Santonian to basal Campanian. *Micraster coranguinum*, *Uintacrinus socialis*, *Marsupites testudinarius* and *Uintacrinus anglicus* zones.

References

Bristow, Mortimore and Wood, 1997; Robinson, 1986; Dowker, 1870; Gale, Wood and Bromley, 1987; Mortimore, Wood and Gallois, 2001.

2.1.2.6 Culver Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. Replaces the mapping member of the same name proposed in Bristow, et al., (1997). The term Culver Chalk Member was used by Mortimore (1987) as part of his Sussex White Chalk Formation.

Type section

Whitecliff Bay [SZ 638 854] on the Isle of Wight.

Primary reference section

Scratchell's Bay [SZ 296 847] on the Isle of Wight; Ballard Point [SZ 048 813] in Dorset.

Formal subdivision

Is divided into the Tarrant Chalk Member and the Spetisbury Chalk Member. Informally includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Soft white chalk, relatively marl free with flint seams. Flints are generally large and in the upper part tabular.

Definition of upper boundary

Conformable at the Portsdown Marl (Mortimore, 1986).

Definition of lower boundary

Conformable. As defined in Mortimore (1986), the base of the Culver Chalk lies low in the *quadrata* Zone, at the Castle Hill Marl. Strong marls commonly occur for

several metres above the Castle Hill Marls, up to and including the Pepper Box Marls which are now taken as the base.

Thickness

From 65 to 75 m and exceptionally 90 m but can be significantly less where synsedimentary channelling occurs.

Distribution

Limited to Sussex, Hampshire, Wiltshire and Dorset and as widely spaced outliers to the north in the Southern Province. Its occurrence and distribution beneath the Quaternary deposits of East Anglia in the Transitional Province is not well known.

Previous names

Culver Chalk Member of Mortimore (1986) and as adopted in Bristow et al., (1997). Includes the Tarrant Chalk and Spetisbury Chalk members.

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Gonioteuthis quadrata* Zone.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997.

Tarrant Chalk Member

Name

Defined in Bristow, Mortimore and Wood (1997) as a stand-alone member in the Upper Chalk Formation. Modified in Rawson et al., (2001) and herein as a member within the Culver Chalk Formation.

Type section

Old pit at the foot of The Cliff, Tarrant Rushton, (see Barton, 1991). Whitecliff Bay [SZ 638 854] on the Isle of Wight.

Primary reference section

Whitecliff Bay [SZ 638 854] on the Isle of Wight.

Formal subdivision

None herein. Informally includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Soft white chalk with relatively widely spaced, but large, flint seams.

Definition of upper boundary

Conformable (but see note below on thickness). Inferred to be at the Whitecliff Flint at the boundary between the Sompting and Whitecliff beds of Mortimore (1986).

Definition of lower boundary

Conformable. As defined by Mortimore (1986), the base of the Culver Chalk lies low in the *quadrata* Zone, at the Castle Hill Marl. Strong marls commonly occur for several metres above the Castle Hill Marls, up to and including the Pepper Box Marls which are now taken as the base. Approximately coincident with the Arundel Sponge Beds.

Thickness

From 35 to 45 m in Sussex, about 30 m in Dorset, but can be considerably reduced where synsedimentary channelling occurs.

Distribution

Limited to Sussex, Hampshire, Wiltshire and Dorset and as widely spaced outliers to the north in the Southern Province. Its occurrence and distribution beneath the Quaternary deposits of East Anglia in the Transitional Province is not well known.

Previous names

None

Parent

Culver Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Gonioteuthis quadrata* Zone.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997; Barton, 1991.

Spetisbury Chalk Member

Name

Defined in Bristow, Mortimore and Wood (1997) as a stand-alone member in the Upper Chalk Formation. Modified in Rawson et al., (2001) and herein as a member within the Culver Chalk Formation.

Type section

Bushes Pit, Bushes Farm, and 1.25 km north-north-west of Winterborne Zelstone. Whitecliff Bay [SZ 638 854] on the Isle of Wight.

Primary reference section

Whitecliff Bay [SZ 638 854] on the Isle of Wight.

Formal subdivision

None herein. Informally includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Firm white flint with regular large flint seams, some tabular in the lower part and of *Zoophycus* type in the upper part.

Definition of upper boundary

Conformable at the Portsdown Marl 1 in the Farlington Redoubt on Portsdown and at Whitecliff Bay, Isle of Wight.

Definition of lower boundary

Conformable (but see note below on thickness). Inferred to be at the Whitecliff Wispy Marls (at Whitecliff Bay) at the boundary between the Sompting and Whitecliff beds of Mortimore (1986).

Thickness

About 30 m at Whitecliff Bay thought to be as thick as 45 m in Dorset and around 35 m in Hampshire.

Distribution

Limited to Sussex, Hampshire, Wiltshire and Dorset and as widely spaced outliers to the north of the Pewsey/Kingsclere structure in the Southern Province. Its possible occurrence and distribution beneath the Quaternary deposits of East Anglia in the Transitional Province is not well known.

Previous names

None

Parent

Culver Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Gonioteuthis quadrata* zone.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore and Wood, 1997; Barton, 1991.

2.1.2.7 Portsdown Chalk Formation

Name

First proposed in Rawson, Allen and Gale (2001) as part of the agreed standard for the Chalk Group of England. The term Portsdown Member was first used in Mortimore (1986) as part of his Sussex White Chalk Formation and adapted to the Portsdown Chalk Member of the Upper Chalk Formation by Bristow, Mortimore and Wood (1997).

Type section

Whitecliff Bay [SZ 638 854] on the Isle of Wight.

Primary reference section

Scratchell's Bay [SZ 296 847] on the Isle of Wight.

Formal subdivision

Includes the Studland Chalk Member. Informally includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Composed of white chalk with marl seams (particularly in the lower part) and flint bands, although less flinty than the Culver Chalk Formation. The lowest part (up to and including the Farlington Marls at the base of the *mucronata* Zone) contains several belts rich in inoceramid shell debris, as well as isolated marl seams and pairs of marl seams that likewise contain much inoceramid shell debris. The highest part is essentially marl-free and termed the Studland Chalk 'Member' of Gale, Wood and Bromley (1987).

Definition of upper boundary

As defined the upper boundary of the formation is the sub-Palaeogene erosion surface. The boundary with the Studland Chalk Member (sensu Gale et al., 1987) is conformable at a marly bed with included marl above which the chalk is marl-free in the Alum Bay/Scratchell's Bay section on the Isle of Wight and at 'the lower horizon of yellow-stained chalk on Old Harry Rock' in Studland Bay, Dorset (Gale et al., 1987). In the Transitional Province the upper boundary is undefined but it is noted (Mortimore, Wood and Gallois, 2001) that the 'highest chalk of the Isle of Wight and Dorset' is equivalent to beds within the Weybourne Chalk Member as formalised by Johansen and Surlyk (1990). These higher beds are informally termed the 'Norwich Chalk' and 'Trimmingham Chalk'.

Definition of lower boundary

Conformable at the Portsdown Marl 1in the Farlington Redoubt on Portsdown and at Whitecliff Bay, Isle of Wight.

Thickness

Around 62 m at Whitecliff Bay but elsewhere thought to be thicker but limited by the sub-Palaeogene erosion surface.

Distribution

Limited to Sussex, Hampshire, Wiltshire and Dorset close to the Palaeogene cover in the Southern Province. Its possible occurrence and distribution beneath the Quaternary deposits of East Anglia in the Transitional Province is not well known.

Previous names

Portsdown Chalk Member of Mortimore (1986) and as adopted in Bristow et al., (1997).

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Campanian. Topmost *Gonioteuthis quadrata* and *Belemnitella mucronata* zones.

References

Rawson, Allen and Gale, 2001; Bristow et al., 1999; Bristow, Mortimore, and Wood, 1997.

Studland Chalk Member

Name

The term Studland Chalk was used by Gale, Wood and Bromley (1987) to describe their highest Campanian chalks at Handfast Point in Studland Bay, it is considered as a member herein.

Type section

Studland Bay between Old Harry Rocks [SZ 0055 825] and the Palaeogene contact [SZ 045 824].

Primary reference section

Alum and Scratchell's Bay [SZ 296 847] Isle of Wight.
Dorset coast at Studland.

Formal subdivision

None herein. Informally includes a number of laterally persistent flint and marl beds named in Mortimore (1986) that can be traced outside Sussex in the Southern and Transitional provinces.

Lithology

Marl-free, soft chalk with large irregular flints.

Definition of upper boundary

The sub-Palaeogene unconformity in the Southern Province. Relationship to the Upper Campanian and Maastrichtian chalks of the north-east Transitional Province is poorly understood due to poor exposure.

Definition of lower boundary

Conformable at a marly bed with included marl, above which the chalk is marl-free in the Alum Bay/Scratchell's

Bay section on the Isle of Wight and at 'the lower horizon of yellow-stained chalk on Old Harry Rock' in Studland Bay, Dorset (Gale et al., 1987). It is not discernible from the published literature whether these two beds are in the same stratigraphic position. This doubt, together with the lack of exposure and geomorphological expression of the member has led to the BGS reverting to the original concept of the Portsdown Chalk Member (Bristow, Mortimore and Wood, 1997). This is also the position stated in Rawson, Allen and Gale (2001) and thus the Portsdown Chalk Formation covers all of the chalk up to the sub-Palaeogene erosion surface.

Thickness

Up to 23 m preserved beneath the sub-Palaeogene unconformity in Alum Bay on the Isle of Wight.

Distribution

Limited to the Isle of Wight and the Swanage area of Dorset in the Southern Province.

Previous names

Studland Chalk of Gale et al., (1987) as adopted informally in Bristow et al., (1997). Perhaps partly equivalent to the informal 'Norwich Chalk' as applied in north Norfolk. Perhaps now considered as a Member within the Portsdown Chalk Formation.

Parent

Portsdown Chalk Formation or White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* s.l. zone.

References

Bristow, Mortimore and Wood, 1997; Rawson, Allen and Gale, 2001; Bristow et al., 1999.

2.1.2.8 Upper Campanian and Maastrichtian Chalk in the Transitional Province

These chalks do not fit within the formal framework applied to the Southern Province and no attempt has been made to correlate these informal units with the upper part of the Flamborough Chalk Formation nor the Rowe Formation of the Northern Province with which they broadly share some characteristics and age. The Upper Campanian chalks are informally designated as the 'Norwich Chalk' as much of the succession has been long studied in numerous pits around Norwich. Peake and Hancock (1961, 1970) split this succession into a number of named units that were tentatively delimited during the survey of the Norwich Sheet 161 and published as a diagram within the memoir (Cox et al., 1989). The Maastrichtian chalks have become known informally as the Trimmingham Chalk and are described in glacially deformed 'erratics' (of considerable size) on the coast between Overstrand and Trimmingham. Again a number of units were given names. Both sets of informal names were given member status in Johansen and Surlyk (1990). All of the succession was investigated in the Trunch Borehole (TG 23 SE 8 [TG 2933 3455]) that was published in the Great Yarmouth Memoir (Arthurton et al., 1994). No firm conclusion has been reached regarding formal nomenclature for these beds since their distribution under a thick Quaternary cover has not been determined. It is recommended that reference to these units be made informally using the Norwich and Trimmingham terms until such time as they can be formally attributed. The development of the terminology applied to this succession is given in Figure 5c.

3 Northern Province Chalk nomenclature

In the Northern Province the Chalk Group has been in use informally for a number of years. Its first formal use was by Rhys (1974) (Figure 11, Column 1) to cover the Chalk in the North Sea and by Wood and Smith (1978) (Figure 6, Column 5) to cover the whole of the Chalk succession in the Northern Province but this also included the Red Chalk (now excluded from the definition as the Hunstanton Formation). Rawson et al., (1978) (Figure 6, Column 6) used the term Chalk Formation to cover the whole of the Chalk (Cenomanian to Maastrichtian). Rawson et al., (2001) (Figure 3, Column 11) formalised the terminology, agreed at the November 1999 meeting, using Chalk Group to cover a lower Grey Chalk Subgroup and a higher White Chalk Subgroup. In the Northern Province the Grey Chalk Subgroup is synonymous with the Ferriby Chalk Formation whilst the White Chalk Subgroup includes the Welton Chalk, Burnham Chalk, Flamborough Chalk and Rowe Chalk formations.

The Chalk Group of England has traditionally been divided into three major units, the Lower, Middle and Upper Chalk (Jukes-Browne and Hill, 1903, 1904; and earlier workers, see History of Research above). The separation of Middle and Upper Chalk was based on the recognition of the Chalk Rock at the boundary in the Southern Province. Unfortunately, this marker bed does not occur in the Northern Province, and consequently the classification is difficult to apply and unsatisfactory for this region. Thus, although the main part of the Chalk succession, as originally mapped by the Geological Survey in the 19th century, was divided into three, the Middle Chalk–Upper Chalk boundary lay at a somewhat indefinite horizon (the base of the *Sternotaxis plana* (now *Plesiocorys plana* Zone) within the median unit of 'Chalk with Flints' (Figure 6, Column 3 and Figure 6, Column 4). To resolve these problems a revised classification was introduced by Wood and Smith (1978) (Figure 6, Column 5) and the scheme used herein is based on their account, as modified by subsequent work (Figure 6).

Jeans (1980) (Figure 5c, Column 3) retained the term Lower Chalk for the succession present across northern England (Norfolk, Lincolnshire and Yorkshire), and introduced a series of members within this division, based on sedimentary cycles that he first identified on the Yorkshire Coast (Belchford, Dalby/Stenigot, Bigby, Candlesby, Nettleton, Louth and Flixton members). Jeans et al., (1991) used two of these terms (Louth, Flixton) in the succession at Dover, Kent, effectively taking a nomenclature established in the thin succession of the East Midlands Shelf, south, into the Anglo-Paris Basin. His members have not been used significantly in subsequent papers.

The 'Lower Chalk' of north Norfolk, Lincolnshire and Yorkshire is different to that further south, as it is characterised by hard chalks with low clay content. Most workers endorse the use of the Ferriby Chalk Formation for this unit. The only significantly different usage is by Jeans, who uses Lower Chalk from north to south, and throughout he applies (member status equivalent) lithological units that are approximately equivalent to the successions identified by Robaszynski et al., (1998) in southern England.

Wood and Smith (1978) (Figure 6, Column 5) divided the Chalk Group of the Northern Province into four formations, in ascending order, the Ferriby Chalk, Welton Chalk, Burnham Chalk and Flamborough Chalk formations, typically some 25, 50, 150 and 260 m in thickness respectively. In the updated scheme used in this account, the basal part of their Ferriby Formation is treated as a separate unit named the Hunstanton Formation (about 3 m thick) and excluded from the Chalk Group. Above the Flamborough Chalk Formation an additional unit, the Rowe Chalk Formation, is recognised beneath the drift cover of Holderness (Figure 6). These six units are based on gross lithological characteristics, such as the presence or absence of flints, and thus the classification can be easily applied in exposures and has the potential for use in field mapping. Given some initial knowledge of the stratigraphical context, the units (with the local exception of the Hunstanton Formation) are potentially recognisable on the basis of geophysical borehole logs alone.

Because the boundary between the Northern and Southern provinces is somewhat diffuse, the Chalk Group in southern Lincolnshire acquires many of the characters of the Southern Province succession. Nevertheless, it is convenient to apply the same Northern Province stratigraphical terminology to the whole of this region. In south Norfolk, to the south of The Wash, the Southern Province terminology is used (but see proviso discussed in Section 3 above and note the use of the term Ferriby Formation as noted above). In the thicker Chalk succession in the Southern North Sea, the same Northern Province units can be recognised though a different nomenclature is used; the Rødby, Hidra, Herring, Lamplugh and Jukes formations correspond approximately with the Hunstanton, Ferriby Chalk, Welton Chalk, Burnham Chalk and Flamborough Chalk formations onshore (Lott and Knox, 1994) (Figure 11, Column 4), and the Rowe Formation is fully developed (note that the Chalk Group as defined in Lott and Knox, 1994, also includes the Ekofisk Formation of basal Palaeogene age throughout the North Sea). BGS Lexicon-style definitions of the component formations of the Chalk Group in Yorkshire and Lincolnshire are given below. The development of the terminology, thickness, distribution and full member and bed description of the formations is discussed in Sumbler (1999) and, within the context of the scheme approved at the November meeting, is summarised below.

The **Hunstanton Formation**, commonly referred to as the Red Chalk, is of Lower Cretaceous (Albian) age. Partly because of this, its lithostratigraphical classification has been controversial. Wood and Smith (1978), Gaunt et al., (1992), Berridge and Pattison (1994) and Sumbler (1996) all regarded it as a part of the Ferriby Chalk Formation (Hunstanton Chalk Member), but many other workers have treated it as a separate formation (e.g. see discussion of Wood and Smith, 1978), or even as a member, included in one discussion with the underlying Carstone (e.g. Kelly and Rawson, 1983). Recent works (Rawson, 1992; Gallois,

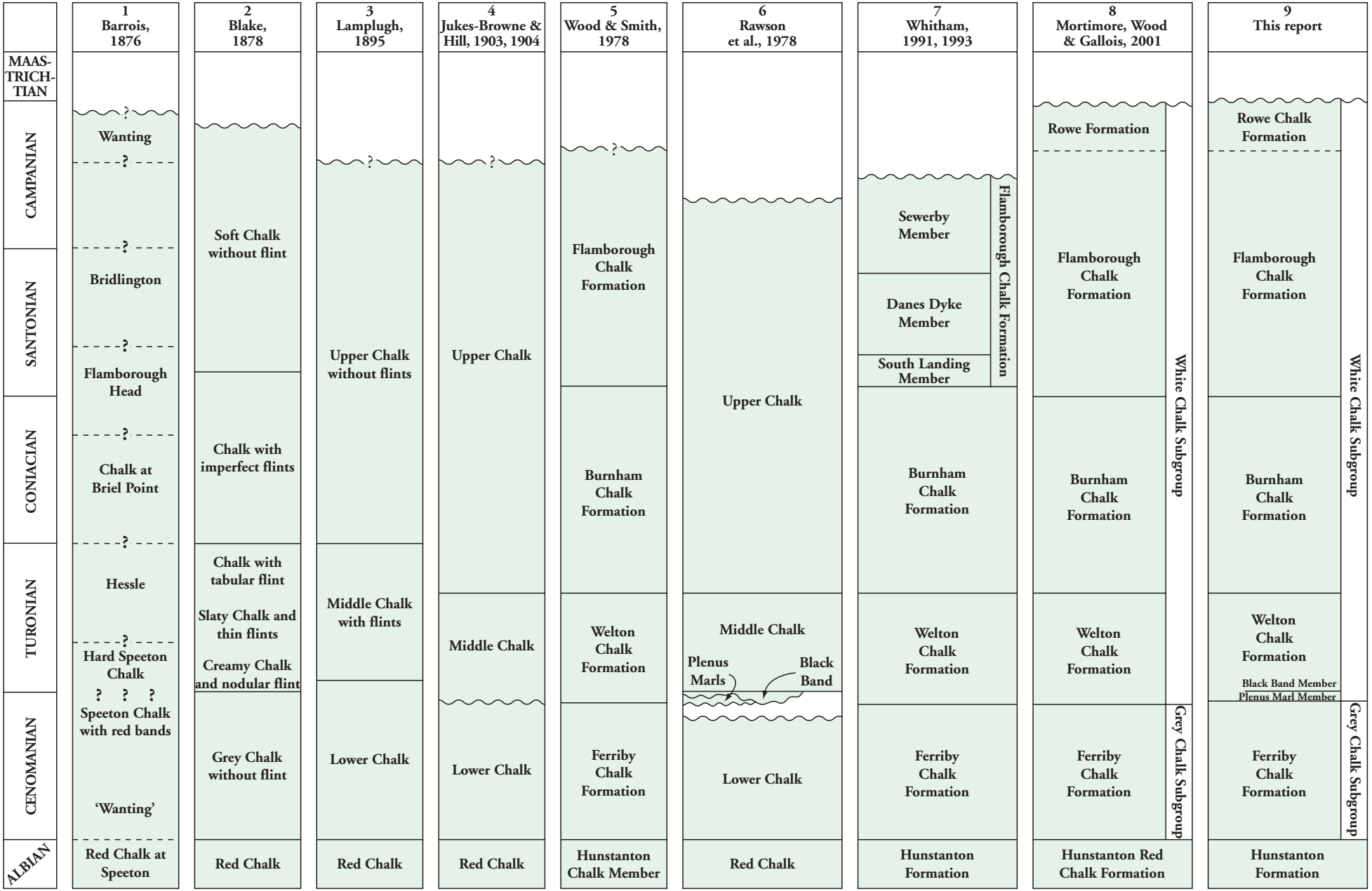


Figure 6 The development of the terminology in the Northern Province.

1994; Owen, 1995, Mitchell, 1995a), whilst disagreeing over the precise nomenclature or indeed whether or not it forms a part of the Chalk Group, all treat it as a distinct formation. The consensus in the meeting held at BGS Keyworth in November 1999 was that it was a formation, but not part of the newly defined Chalk Group, and as defined it is older than the major hiatus at the base of the Cenomanian.

The Hunstanton Formation is present throughout Yorkshire and Lincolnshire, and extends southwards to the type locality of Hunstanton [TF 67 40] on the north Norfolk coast, but only a few kilometres south it passes into mudstones of the Gault Formation (Gallois, 1994). At Hunstanton, it comprises about 1 m of reddish brown, sandy chalk or limestone with marl seams; its top is defined by an erosion surface that marks the striking change in colour with the overlying off-white chalks (Owen, 1995).

North of The Wash, the Hunstanton Formation thickens substantially, averaging about 3 m over the East Midlands Shelf, e.g. at South Ferriby Quarry [SE 99 20] (Gaunt et al., 1992; fig 3), an important reference section that is more typical of the formation in general than is the type section at Hunstanton and may be better regarded as a replacement type section therefore. It comprises marls and both rubbly and massive chalks that are mainly a distinctive pink to brick-red colour caused by disseminated hematite. It overlies the Carstone Formation with the contact between the two formations commonly gradational, although non-sequential with phosphatised burrows in places.

A thin 1 m succession more like that at Hunstanton, is developed over the Market Weighton High where it also includes the few centimetres of the Carstone (Jeans, 1973) and rests unconformably on Jurassic mudstones. A thick (24 to 30 m) and more complete succession, overlying the Speeton Clay, is developed in the Cleveland Basin (*strictly a term applicable to the Jurassic strata only but commonly used as a shorthand for the thicker Cretaceous strata north of the Flamborough – Dowsing Fault Zone, succession that have affinities to the Central North Sea Basin*), in the cliffs at Speeton [TA 165 751] (Wright, 1963; Jeans, 1973, 1980; Neale, 1974; Mitchell, 1995a), and possibly in boreholes inland around Fordon. The top of the formation as now defined is marked by a well-defined burrowed horizon (Mitchell, 1995a).

The succession at Hunstanton has been divided into a number of units based on criteria such as lithology and fossil assemblages (Andrews, 1983; Owen, 1995). The sections at South Ferriby Quarry (Morter, in Gaunt et al., 1992), and Speeton (Mitchell, 1995a) have likewise been subdivided, a correlation between the three sites, and a formal nomenclature, is suggested by Mitchell (1995a).

The **Ferriby Chalk Formation** corresponds approximately to the Lower Chalk of many previous accounts, although some included the sub-Black Band marls (now Plenus Marls Member) at the top. Rawson et al., (2001) exclude the Plenus Marls Member from this formation. Its type locality is South Ferriby Quarry [SE 9915 2045] (Wood and Smith, 1978; Gaunt et al., 1992).

The Ferriby Chalk Formation is dominated by grey, marly chalk, which weathers to buff in exposures, and gives rise to rather marly soils. It is flint-free throughout, and was mapped as 'Chalk without Flints' by the Geological Survey in the 19th century. As well as marly chalks with some discrete marl bands, 'gritty' bioclastic chalks and hard, cemented chalks occur, defining a number of sedimentary rhythms (Jeans, 1980). This rhythmicity is thought to have been climatically controlled and related to periodic variations in the Earth's orbital and rotational parameters (Milankovitch cycles; e.g. Gale, 1995). Most of the named marker beds can be traced throughout the Northern Province and have been used to define seven members (Jeans, 1980), although these members have not gained widespread use. The marker beds are, in ascending order, the Paradoxica Bed (or Sponge Bed; the Belchford Member of Jeans, 1980; the Crowe's Shoot Member of Mitchell, 1995a); the Lower Inoceramus Bed; the Upper Inoceramus Bed; the Lower Orbirhynchia Bed; the Totternhoe Stone (the Grey Bed of Hill, 1888) (note that the erosion surface beneath this marker bed is recognised in the Southern Province as the base of the Zig Zag Member); Upper Orbirhynchia Bed (Jeans, 1980); the Lower Pink Band; the Nettleton Pycnodonte Bed (formerly Gryphaea Band); the Nettleton Stone (the Nettleton Member or 'Three-feet-six-inch Bed' of Jeans, 1980; the 'Jukes-Browne Band' of Murray, 1986); and the Upper Pink Band.

Apart form its lowest beds; the **Welton Chalk Formation** is dominated by massive or thickly bedded chalk containing flint nodules (as distinct from tabular flints). It comprises the lower part of the unit of 'Chalk with Flints' shown on early geological maps and corresponds approximately with the Middle Chalk of earlier accounts (Jukes-Browne and Hill, 1904), though the latter excluded the basal beds (Plenus Marls Member) of the Welton Chalk Formation. Rawson et al., (2001) (Figure 3, Column 11) in unifying the base of the White Chalk Group, in both the Northern and Southern provinces, at the base of the Plenus Marls Member effectively included the Plenus Marls Member within the Welton Chalk Formation, thus defining the base of this formation at the sub-plenus erosion surface.

The correlation of the **Plenus Marls and Black Band members** within the base of the Welton Chalk Formation has been 'one of the most contentious and unresolved issues in English Chalk stratigraphy' (Wood and Mortimore, 1995). This contention has rested on the placing of the distinctive Black Band and associated beds of the Northern Province with respect to the Plenus Marls of Jefferies (1963) in the Southern Province.

The succession is a thin but complex unit of yellow-brown to green coloured marls and marly chalk with at least two distinct 'black' marl bands marking anoxic depositional conditions. They generally form a hollow at outcrop corresponding to the base of the formation. This marly succession can be recognised in boreholes from its distinctive geophysical log signature. The member is generally about 0.5 to 1.4 m thick but is much thinner in south Lincolnshire.

The earliest references to this succession all describe, in varying levels of detail, multicoloured (including black) laminated or shaly clay (Judd, 1867; Blake, 1878; Dakyns and Fox-Strangways, 1886; Dakyns et al., 1886) and the term 'black band' came into use. Hill (1888) described 'the zone of *Belemnitella plena*' which always included 'dark grey, in places almost black' marl in the centre of a thin marly succession. Rowe (1904) described the 'black band' at Speeton [TA 19 74] and regarded it as the Yorkshire equivalent of the Plenus Marls. Wright and Wright (1942), quoting the section published in Hill (1888), used the 'Black Band' to cover their Bed 7 (an amalgamation of Beds 9 to 11 of Hill). In so doing formally extending the term to include the marly beds above and below the black band itself.

Wood and Smith (1978) treated this thin succession (their 'Basal Beds') as the lowest unit of the Welton Chalk Formation. They reserved the formal name of the Black Band for the bed of 'dark laminated marl lying in the middle of a complex of marls' and this classification was generally accepted. Jeans (1980) used the name 'Flixton Member', and Whitham (1991) the term 'Plenus Marls complex' to cover the same interval. Wood and Mortimore (1995) preferred the term 'Variegated Beds' to cover the 'standard Black Band succession of eastern England (Northern Province)' to avoid confusion. Dodsworth (1996) has divided the succession into eight units (Beds A to H) that can be correlated across the region.

The base of the succession (and thus of the Welton Chalk Formation) rests upon an erosion surface (see above) that is often highly irregular, and may be stained with iron minerals and glauconite. The belemnite *Actinocamax plenus* (now *Praeactinocamax plenus*) has been recorded (Jefferies, 1963; Whitham, 1991, Gaunt et al., 1992) from the basal beds (A and B of Dodsworth, 1996). This demonstrates the equivalence of this part of the succession to the Plenus Marls as developed in Southern England. The Black Band (Beds C, D and E of Dodsworth, 1996) in the middle or upper part of the succession is generally 20 or 30 cm thick. The Black Band comprises very dark grey to black or purplish bituminous marl indicating nearly anaerobic bottom conditions (the so-called Oceanic Anoxic Event) at the Cenomanian-Turonian stage boundary (Hart and Bigg, 1981). However, higher parts of the member (the Black Band proper and above) post-date the youngest part of the Plenus Marls of the south, being equivalent to the basal part of the Melbourn Rock (the Meads Marls succession) (Jefferies, 1963; Wood and Mortimore, 1995).

Wood et al., (1997) described an expanded Cenomanian-Turonian Boundary succession in new excavations at Melton Ross Quarry. They described a 'Central Limestone' (equivalent to Bed A of Dodsworth, 1996 in the standard Lincolnshire succession), which they also equated with the Plenus Marls Bed 3 of Jefferies (1963). The succession below, and hitherto unrecorded in the literature, they divided into Beds I to VII and equated to Jefferies Beds 1 and 2. The Central Limestone (divided by them into Beds 1 to 4) and beds above (Beds 5 to 10) they regarded as equivalent to the standard Lincolnshire succession previously described by Dodsworth (1996). Bed 7 (a to c) they equated to the Black Band sensu stricto (Beds C to E of Dodsworth, 1996). Bed 5 of Wood et al., (1997) contains the belemnite from which the Plenus Marls takes its name but it is not stated whether they believe their Bed 6 to be equivalent to the higher Plenus Marls succession or to the post-plenus succession.

The Black Band does not occur south of the neighbourhood of Louth (Bower and Farmery, 1910; Wood, 1980; Hart et al., 1993; Dodsworth, 1996), so that the succession in the south of the region is much like that of Southern England.

Thus, to achieve equivalence between the provinces, the term Plenus Marls Member as applied to the Northern Province should be restricted to those beds beneath the Black Band. The Black Band and marl beds above up to the incoming of inoceramid debris are equivalent to part of the Melbourn Rock Member of the Southern Province and perhaps demands the status of a separate Black Band Member (proposed herein).

The **Welton Chalk Formation above the Plenus Marls and Black Band members** corresponds with the lower half of the unit of 'Chalk with Flints' shown on early geological maps of the region. In full successions the Black Band Member (herein defined, see below) is succeeded by several metres of gritty chalks containing abundant shells and shell debris of the inoceramid bivalve *Mytiloides labiatus*, the zonal index fossil. These beds correspond with the upper part of the Melbourn Rock and the overlying part of the Holywell Nodular Chalk Formation of the Southern Province. At Speeton, Mitchell (2000) has named this 2.2 m thick unit the Buckton Member.

Above these basal shelly chalks, the bulk of the Welton Chalk Formation is composed of pure, white chalk with flint. It is 43 m thick at the type locality (Whitham, 1991) thinning slightly to the south. This unit is thicker on the Yorkshire coast where Mitchell (2000) recorded about 51 m. There are conspicuous flint bands and marl seams, of bed status, forming important markers (Wood and Smith, 1978; Gaunt et al., 1992; Whitham, 1991).

The Melton Ross Marl, about two-thirds up in the Welton Chalk Formation is the most prominent marker in sections and boreholes, and being identified with the Southerham Marl of Sussex (Mortimore and Wood, 1986), is crucial in the framework of inter-province and regional correlation.

The **Burnham Chalk Formation** is characterised by thinly bedded chalk with common tabular and semi-tabular (discontinuous) flint bands. It forms the upper part of the 'Chalk with Flints' of early geological maps, or the lower part of the Upper Chalk of Jukes-Browne and Hill (1904). The chalk in the lower part of the formation is particularly hard, and forms a conspicuous outstanding feature, facilitating mapping of the base of the formation in the drift-free areas.

The type locality for the base of the formation is the disused Burnham Lodge Quarry [TA 0685 1720] south of Barrow upon Humber. The succession in the overlying beds has been pieced together from various quarries and boreholes, particularly those drilled at Killingholme [TA 16 19] (Wood and Smith, 1978; Gaunt et al., 1992; Berridge and Pattison, 1994; Whitham, 1991).

As in the Welton Chalk Formation, marl seams and flint bands form widespread marker horizons, in addition to several bands of thinly laminated chalk which are also useful for correlation. The chalks become softer in the southern part of the Province, indicative of the transition towards the Southern Province succession.

The lowest few metres of the formation are characterised by hard chalk and thick, closely spaced, tabular flints, and equates with part of the Brandon Flint Series of Norfolk (this series is the flint maximum within the upper Turonian and is further equated with the 'Basal Complex' in Kent and the succession from the Bridgewick to BoPeep flints in Sussex thus demonstrating this part of the lower Lewes Nodular Chalk Formation is equivalent to the mapped base of the Burnham Chalk Formation). Rare specimens of the ammonite *Hyphantoceras reussianum* (Orbigny) from the beds just below and above the Wootton Marls (Gaunt et al., 1992; Whitham, 1991), suggest an approximate equivalence to the Chalk Rock Member within the Lewes Nodular Chalk Formation in the Southern Province.

The Little Weighton Marls or the 'Conoco Marls' of Barker et al., (1984), are three thin marl seams (typically 2 cm) within 2 to 3 m of chalk. The lower two of the three marls are thought to correlate with the paired East Cliff or Shoreham Marls of the Southern Province. The upper of these two marls (corresponding with Little Weighton Marl 2)

is taken to mark the base of the *Hagenowia rostrata* Zone, which corresponds approximately with the base of the *Micraster coranguinum* Zone of the Southern Province. The irregular semi-tabular Eppleworth Flint, about 30 cm thick and generally about 65 to 70 m above the base of the formation, is probably the most substantial flint band in the entire succession, possibly equating with the East Cliff Semitabular or Seven Sisters Flint of the Southern Province (Mortimore and Wood, 1986).

The succeeding beds are massive chalk with marl partings and small lenticular and nodular flints with two notable markers: the De la Pole Flint and the Middleton Marl (or East Halton Marl). The higher beds of the Burnham Chalk Formation are poorly known inland except from boreholes and typically contain pale grey lenticular flints, and bands of small nodular flints, often associated with thin marly laminae. A notable marker bed, 26 m above the Middleton Marl, proved in a borehole [TA 1732 1905] at Killingholme is a carious tabular flint overlain by chalk with *Inoceramus* shell debris (Berridge and Pattison, 1994). Several boreholes in this area prove a white, or incipient flint, some 14 m higher. This appears to be the highest substantial flint in the succession and it therefore defines the top of the formation. At Flamborough Head, and in the cliffs to the north, the topmost flint is known as the High Stacks Flint (Whitham, 1991). Inland in a quarry section at Langtoft [SE 973 512] (Whitham, 1991) it remains uncertain whether or not the topmost flint is at the same stratigraphical horizon, but it seems unlikely.

The **Flamborough Chalk Formation** is the youngest formation recognised in the Chalk exposed at outcrop in this region. It is essentially flint-free, and comprises the upper unit of 'Chalk without flints' mapped by the Geological Survey in the 19th century. Much of the succession is also generally less hard than the chalk in the underlying Burnham Chalk Formation, being lithologically similar to the chalks of southern England.

The cliffs constituting the type section of the Flamborough Chalk Formation are described by Lamplugh (1895), Rowe (1904), Neale (1974), Rawson and Whitham (1992), Whitham (1992; 1993) and Mitchell (1994; 1995b). The succession is difficult to measure accurately, because of cliff falls, minor structures and some gaps in exposure, and it is likely that all these accounts contain minor errors. The most complete and detailed description is by Whitham (1993), who introduced names for various marker beds. However, because of the lack of comparative sections elsewhere, it remains uncertain how laterally persistent these named markers are, or to what degree the stratigraphy of the designated type section is representative of the formation on a regional basis.

At the type section, the formation comprises white, flint-free chalk with numerous regularly spaced marl seams typically 1 to 3 cm thick. Some of the thicker marls named as marker horizons are seen to vary greatly in thickness, or split into multiple bands when traced laterally over fairly short distances, and this inevitably complicates correlation with sections elsewhere. Whitham (1993) subdivided the succession at the type section into three members, the South Landing, Danes Dyke and Sewerby members, which have somewhat different lithological characteristics.

The South Landing Member, about 21 m thick, comprises hard chalk with sporadic thin marl seams. The base of the member (and of the Flamborough Formation) is marked by the top of the High Stacks Flint, seen on the foreshore near High Stacks, Flamborough Head [TA 258 704]. About 3 m above is the High Stacks Marl, a 2 cm thick, grey, silty marl marker, with a thinner marl about 1 m below. This marker has not been observed at Langtoft Quarry [TA 012 661] north of Driffield, which also exposes the basal beds of the Flamborough Chalk Formation (Whitham, 1991), but it is unclear whether this indicates that the marl is discontinuous, or whether the base of the flint-free Flamborough chalks lies at a different horizon there. At the top of the member, a 1 m bed of relatively fossiliferous chalk with inoceramids, echinoids, and sponges, is overlain by the South Cliff Marl (Whitham, 1993), and regarded by him as being several metres below the top of the member. However, according to Mitchell (1994), it is the same as the East Nook Marl at the base of the succeeding Danes Dyke Member.

The Danes Dyke Member is about 67 m thick and comprises thinly bedded, alternating hard and soft chalk with stylolites, and with common marl seams (86 in total), some of which are named (see Witham, 1993; Mitchell, 1994). It is less hard than the underlying South Landing Member, and the marls are far more abundant. The lowest are the three East Nook Marls, which occur in the basal few metres of the member. The base is marked by East Nook Marl 1, a grey, rather chalky marl seam, 2 to 3 cm thick. The peculiarly shaped echinoid *Hagenowia* occurs fairly commonly in the chalks associated with these three marls, indicating the H. *rostrata* Zone. The base of the succeeding *Uintacrinus socialis* Zone, between 40 and 45 m thick, is defined by the first appearance of the zonal crinoid a few metres above. The *Marsupites testudinarius* Zone occurs in the upper third of the member above the lower of the Maidlands Upper Marls pair.

The Sewerby Member constitutes the highest chalks exposed on the coast. Massive chalk dominates the sequence although the lower part comprises thinly bedded chalk with stylolites, much like the bulk of the underlying Danes Dyke Member. Marl seams are somewhat less common than in the Danes Dyke Member. About 71.5 m of beds are seen on the coast with (probably) slightly higher horizons being represented in quarries inland, although precisely how these inland sections relate to the coast is not certain.

The lowest of the Danes Dyke Upper Marls marks the base of the member. Plates of the zonal crinoid *Marsupites* are common at some levels in the chalk associated with these marls, and in the succeeding 5 m or so. A bed with abundant inoceramid shell debris about 13 m above the base of the member was formerly taken as the base of the *Sphenoceramus (Inoceramus) lingua* Zone, but these beds are now assigned to the *Uintacrinus anglicus* Zone, defined by the range of that crinoid (Mitchell, 1995b), and taken as the basal zone of the Campanian Stage.

Inland, quarries at Bessingby [TA 164 669] (Whitham, 1993) and at various localities around Bridlington (Rowe, 1904; Wright and Wright, 1942) expose chalk with marl bands that lie at a slightly higher stratigraphical level than those on the coast. A section at White Hill Reservoir [TA 165 713], Bridlington (Wright and Wright, 1942) is thought to have exposed the youngest chalk represented at outcrop inland. These beds probably belong to the *Gonioteuthis quadrata* Zone (Figure 2).

The **Rowe Chalk Formation** are the youngest chalks of the region and occur in the coastal area of Holderness, where it is concealed beneath glacial drift deposits up to 50 m thick. Southwards from Hornsea, the total thickness of chalk strata above the Burnham Chalk Formation is approximately 300 to 350 m. Microfaunal evidence from boreholes indicates that the beds here extend into the *Belemnitella*

mucronata Zone, and specimens of the index belemnite have been found in the tills which cover the chalk of this area (Wood, 1980). Chippings and geophysical data from hydrocarbon wells in the Hornsea area would suggest that the largely flint-free chalks typifying the Flamborough Chalk Formation are about 260 to 280 m thick and are overlain by about 70 m of flint-bearing chalk. These flinty strata, and still higher beds, continue eastwards beneath the North Sea where they have been named the Rowe Formation (Lott and Knox, 1994). The base is thought to lie approximately at the base of the *Belemnitella mucronata* Zone.

A digest of the development of terminology in the Northern Province is given in Figure 6 and the lithostratigraphical units recommended for use on maps and in memoirs are listed in Table 3.

3.1 CHALK GROUP

For definition see Section 2.1

3.1.1 Grey Chalk Subgroup

For definition see Section 2.1.1

3.2.1.1 Ferriby Chalk Formation

Name

The Ferriby Chalk Formation was first proposed by Wood and Smith (1978) as a replacement for the Lower Chalk as applied to the Northern Province. This paper included the Hunstanton Chalk Member (Red Chalk) at the base of the formation that is excluded by later workers (e.g. Mitchell 1991, 1993). Herein the term also excludes the Hunstanton Formation.

Type section

South Ferriby Quarry [SE 9915 2045] (Gaunt et al., 1992).

Reference section

Speeton Cliffs [TA 162 752 to TA 192 744] (Wright, 1968; Mitchell, 1995a).

Formal subdivision

None herein but the formation includes a number of named units that are considered of bed status (see Wood and Smith, 1978). Jeans (1980) proposed a scheme of seven members but this has not gained widespread use in the literature.

Lithology

Grey, soft, marly, flint-free chalk, typically weathering buff in exposures; locally includes pinkish bands; some harder, gritty, shell-debris-rich beds, and thin discrete marl seams.

Definition of upper boundary

Uneven erosion surface that may be stained with iron minerals and glauconite, at the top of a succession of marly chalk (Ferriby Chalk Formation) and a little way above the so called Upper Pink Band (of bed status). This surface is succeeded by a thin unit of marls and marly chalks (the Plenus Marls Member, Welton Chalk Formation), which generally forms a topographical slack at outcrop. This facilitates the mapping of the top of Ferriby Chalk Formation, which is also readily recognised from geophysical log signature in boreholes.

Definition of lower boundary

At an erosion surface, locally developed on a hardground, overlain by nodular chalk (lowest Cenomanian) of Paradoxica (or Sponge) Bed or, in the Cleveland Basin, the flaser-bedded white chalks with red or purple marls of the Crowe's Shoot Member (Gaunt et al., 1992; Mitchell, 1995a).

Thickness

The formation is typically about 20 to 25 m thick throughout the southern part of the region. It thins to 10 to 15 m over the Market Weighton High (Jeans, 1973) and its extension to Hornsea. It thickens immediately at the margin of the Cleveland Basin to the north, being 33 to 35 m thick on the coast at Speeton (Wright, 1963; Jeans, 1980), and possibly 50 m or more in boreholes inland near Fordon.

Distribution

Throughout Yorkshire and Lincolnshire.

Previous names

'Chalk without Flints' or 'Lower Chalk' of early Geological Survey maps, but excluding Plenus Marls; Ferriby Chalk Formation (in some cases this includes the basal unit now separated as the Hunstanton Formation).

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian (*Mantelliceras mantelli* to *Calycoceras guerangeri* Zone).

References

Wood and Smith, 1978; Gaunt et al., 1992; Whitham, 1991.

3.1.2 White Chalk Subgroup

For definition see Section 2.1.2

3.1.2.1 Welton Chalk Formation

Name

The Welton Chalk Formation was proposed by Wood and Smith (1978).

Table 3 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of the Northern Province of England.

Name of unit	Lexicon code	Map symbol
Black Band Member	None	None
Burnham Chalk Formation	BCK	BCk
Ferriby Chalk Formation	FYCK	FyCk
Flamborough Chalk Formation	FCK	FCk
Hunstanton Formation	HUCK	HCk*
Plenus Marls Member	PLMA	None
Rowe Chalk Formation	ROWE	ROWE
Welton Chalk Formation	WCK	WCk

*this is the same map symbol as that used for the Holywell Nodular Chalk Formation of the Southern Province and it is recommended that this Northern Province symbol be changed to HuCk to avoid confusion.

Notes: For definitions of the Chalk Group and its component Subgroups refer to the entries within Section 3 above. An entry is included for the Hunstanton Formation (Red Chalk) because of its historical association with the Chalk Group but from which it is now formally excluded.

Type section

Melton Bottoms (Welton Wold) Quarry [SE 970 282] near North Ferriby, Yorkshire (Gaunt et al., 1992; and Whitham, 1991).

Reference section

Bempton and Buckton coastal cliffs between North Landing and Speeton [TA 239 721to TA 165 750] (because of inaccessibility and structural complications, the section has never been described in detail, but see for example Rowe, 1904; Neale, 1974; Rawson and Whitham, 1992).

Formal subdivision

Includes at its base the Plenus Marl Member and the Black Band Member both defined herein. There are many named marl and flint bands throughout the succession that are used to divide the formation. They are all of bed status.

Lithology

White, massive or thickly bedded chalk with common flint nodules ('burrow-form flints') but generally lacking tabular flint bands; sporadic marl seams including the Plenus Marls Member ('Black Band' sensu lato) at the base.

Definition of upper boundary

Marked change from massive, rubbly-weathering chalks below, to harder, thinly bedded or nodular chalk (Burnham Chalk Formation) above. This horizon is found just below the Ravendale Flint, a tabular or semi-tabular flint up to 0.25 m thick, which is the lowest such flint in the Chalk Group and base of the chalk unit in which such flint bands are common.

Definition of lower boundary

Base of Plenus Marls Member, a unit of buff to green and grey marls and marly chalks, typically 0.5 m thick, but up to 1.4 m in Cleveland Basin. This rests on an uneven erosion surface that may be stained with iron minerals and glauconite, at the top of a succession of marly chalk (the Ferriby Chalk Formation). The marly basal beds generally form a topographical slack at outcrop, which facilitates the mapping of the base of the formation, and can also be recognised from their geophysical log signature in boreholes.

Thickness

The formation is approximately 53 m thick in the Burnham–Melton Ross area in the central part of the region, and at the type locality of Melton Bottoms or Welton Wold Quarry [SE 970 282]. It is thinner in the south, the equivalent beds averaging about 33 m in north Norfolk (Peake and Hancock, 1970) (Figure 5c, Column 2). It also may thin slightly across the Market Weighton High, perhaps to as little as 40 m in places, but thickens again into the Cleveland Basin where the gamma-ray log of the Fordon No 2 borehole [0689 7360] suggests it is about 55 m thick. Whilst Rowe (1904; see also Neale, 1974) suggests it is about 68 m thick in the Bempton and Buckton cliff sections between Flamborough and Speeton, according to Mitchell (2000) it is only 55 m (cf. Fordon) at Speeton, its most northerly outcrop. Curiously, however, at Thornwick Bay, at the south-eastern end of this section, measurement of the upper and greater part of the formation (see Whitham, 1991, (Figure 6, Column 7); Mitchell 2000) shows that it is slightly expanded relative to Speeton, suggesting a total of at least 60 m there. This may indicate an eastward thickening towards the offshore extension of the Cleveland Basin, or an error in one or other of these sections, possibly related to structural complications.

Distribution

Throughout Yorkshire and Lincolnshire.

Previous names

'Chalk with Flints' (lower part) of early Geological Survey maps. Middle Chalk plus uppermost part (Plenus Marls) of Lower Chalk.

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian (*Metoicoceras geslinianum* Zone) to Turonian (*Terebratulina lata* Zone).

References

Wood and Smith, 1978; Gaunt et al., 1992.

Plenus Marls Member

Name

The Plenus Marl Member as defined in Sumbler (1999) included beds A to H of Dodsworth (1996) and thus contained the Black Band. It is herein proposed to redefine the term to include only beds A and B of Dodsworth with the higher beds C to H forming the newly proposed formal term Black Band Member (see below). In so doing the Plenus Marl Member as defined in the Northern Province is the direct equivalent of the member as described for the Southern Province.

Type section

Melton Ross Quarry, Lincolnshire [TA 082 112].

Reference section

South Ferriby Quarry, Lincolnshire [SE 9915 2045].
Melton Bottom upper quarry [SE 970 280] the stratotypes for the whole Welton Chalk Formation.

Formal subdivision

None

Lithology

Thinly bedded dark-coloured calcareous mudstone (marl) overlain by rubbly limestone and calcareous silty beds followed by a higher calcareous mudstone siltstone (marl).

Definition of upper boundary

Conformable at the base of the Black Band (the 'Main Black Band' of Wood et al., 1997), the lowest unit of the Black Band Member.

Definition of lower boundary

An uneven erosion surface that may be stained with iron minerals and glauconite, at the top of a succession of marly chalk (the Ferriby Chalk Formation). This member and the newly proposed Black Band Member above, generally form a topographical slack at outcrop, which facilitates the mapping of the base of the Welton Chalk Formation, and can also be recognised from its higher gamma-ray geophysical log signature in boreholes.

Thickness

About 1.15 m at type site but to as little as 0.25 m elsewhere.

Distribution

Not known in detail but it is suspected that this member forms part of the succession formerly identified as the Black Band in boreholes and seismic sections.

Previous names

Equivalent as defined herein to the Plenus Marls (Member) of Jefferies (1963) and the Plenus Marls Member as defined herein in the Southern Province. Equivalent to Beds A and B of Dodsworth (1996). Lower part of the Flixton Member of Jeans (1980). Lower part of the Plenus Marls Member of Witham (1991). Lower part of the Basal Beds including the Black Band in Gaunt, Fletcher and Wood, (1992). Lower part of the Variegated Beds of Wood and Mortimore (1995) also referred to as the 'expanded standard Black Band Succession' by Wood et al., (1997).

Parent

Welton Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian (*Metoicoceras geslinianum* Zone).

References

Dodsworth, 1996; Sumbler, 1999; Wood and Mortimore, 1995; Wood, Batten, Mortimore and Wray, 1997.

Black Band Member

Name

The Black Band Member is formally proposed herein. It is equivalent to beds C to H of Dodsworth (1996) and together the Black Band (bed) itself and superposed Variegated Beds of Wood and Mortimore (1995).

Type section

South Ferriby Quarry, Lincolnshire [SE 9915 2045].

Reference section

Melton Ross Quarry, Lincolnshire [TA 082 112]. Melton Bottom upper quarry [SE 970 280] the stratotype for the whole Welton Chalk Formation.

Formal subdivision

None

Lithology

Interbedded black or very dark carbonaceous calcareous mudstone (the Black Band) and variegated calcareous mudstone (marl) succession terminating in the 'sticky green clay' (Wood and Mortimore, 1995).

Definition of upper boundary

Conformable at the junction between a sticky green clay (Bed 6 i.e. the top of the 'Variegated beds, in fig 4, Wood and Mortimore, 1995) and an extremely condensed succession of shell-detrital limestones with some thin very dark 'marl' seams.

Definition of lower boundary

Thickness

Generally about 0.5 to 0.6 m but up to 1.4 m in the Cleveland Basin.

Distribution

A well-known marker throughout the Northern Province and in the offshore areas.

Previous names

Equivalent, as defined herein, to the Melbourn Rock Member (Meads Marls) in the Southern Province. Equivalent to Beds C and H of Dodsworth (1996). Upper part of the Flixton Member of Jeans (1980). Upper part of the Plenus Marls Member of Witham (1991). Upper part of the Basal Beds including the Black Band in Gaunt, Fletcher and Wood, (1992). Upper part of the Variegated Beds of Wood and Mortimore (1995) also referred to as the 'expanded standard Black Band Succession' by Wood et al., (1997).

Parent

Welton Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian (*Neocardioceras juddi* zone) to Turonian (*Mytiloides spp*. Zone).

References

Dodsworth, 1996; Sumbler, 1999; Wood and Mortimore, 1995; Wood, Batten, Mortimore and Wray, 1997.

3.1.2.2 Burnham Chalk Formation

Name

The Burnham Chalk Formation was proposed by Wood and Smith (1978).

Type section

Burnham Lodge Quarry [TA 0685 1720] near Barrow upon Humber, Lincolnshire (Gaunt et al., 1992).

Reference section

Coastal cliffs north-west of Flamborough Head [TA 259 705 to about TA 175 748] (this section has never been described in detail, but see e.g. Rowe, 1904; Neale, 1974; Rawson and Whitham, 1992, a, b).

Formal subdivision

None herein but there are many named marl and flint bands throughout the succession that are used to divide the formation. They are all of bed status.

Lithology

White, thinly bedded chalk with common tabular and discontinuous flint bands; sporadic marl seams.

Definition of upper boundary

Top of highest flint band within a flint-rich unit of chalk (i.e. Burnham Chalk Formation) succeeded by flint-free chalks (i.e. Flamborough Chalk Formation); at Flamborough Head, this is the High Stacks Flint, but elsewhere may be at a somewhat different horizon. Change particularly marked on borehole sonic velocity logs.

Definition of lower boundary

Marked change from massive, rubbly-weathering chalks below, to harder, thinly bedded or nodular chalk above. This horizon lies just below the Ravendale Flint, a tabular or semi-tabular flint up to 0.25 m thick that is the lowest such flint in the Chalk Group and base of the chalk unit in which such flint bands are common. The lowest few metres of the formation comprise hard chalks and thick, closely spaced, tabular flint which produce a topographic feature by which the base of the formation can be mapped, and a characteristic geophysical log signature enabling its identification in boreholes.

Thickness

The formation is about 130 m thick; equivalent beds in north Norfolk are approximately 100 m thick (based on

Wood et al., 1994), suggesting thinning of the Burnham Chalk Formation in the south of the region. North of the Humber, the Burnham Chalk Formation is 140 m thick (Whitham, 1991) but thins to 85 to 100 m over the Market Weighton High. A complete section of the formation is exposed in the cliffs north of Flamborough Head, from Selwicks Bay to North Landing where Rowe (1904) recorded a thickness of 105 m. However, bed-by-bed measurements of the lower part of the formation indicate that it is thicker, perhaps 160 m for the whole formation. The difference in these figures suggests that the top of the formation in the Cleveland Basin (as defined by the presence of flints) lies at a lower horizon than in the south, perhaps just above the Middleton Marl (based on preliminary correlation of geophysical logs).

Distribution

Known throughout the Northern Province.

Previous names

'Chalk with Flints' (upper part) of early Geological Survey maps.
Upper Chalk (lower part).

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Turonian to Santonian (*Sternotaxis plana* (now *Plesiocorys plana*) to *Micraster coranguinum* zones).

References

Wood and Smith, 1978; Gaunt et al., 1992; Whitham, 1991.

3.1.2.3 Flamborough Chalk Formation

Name

Flamborough Chalk Formation was proposed by Wood and Smith (1978).

Type section

Cliff section Sewerby Steps and High Stacks, Flamborough Head [TA 201 687 to TA 259 705] (Whitham, 1993; Mitchell, 1994, 1995b).

Reference section

Atwick No 2 (1973) borehole (TA 15 SE/9) [TA 1835 5171], from about 122 m to about 385 m.

Formal subdivision

None herein. Divided into three members by Whitham (1993) that are in ascending order the South Landing Member, Danes Dyke Member and the Sewerby Member. There are many named marl units of bed status.

Lithology

White, well-bedded, flint-free chalk with common marl seams (typically about one per metre). Stylolitic surfaces and pyrite nodules are common.

Definition of upper boundary

Base of lowest flint of succeeding thick, flint-rich unit (i.e. Rowe Formation).

Definition of lower boundary

Top of highest flint band of underlying thick, flint-rich unit of chalk (i.e. Burnham Chalk Formation); in type section this is the High Stacks Flint but elsewhere may be at a somewhat different horizon.

Thickness

The type section, between Flamborough Head and Sewerby, exposes the basal about 160 m of the formation. Equivalent, and probably slightly higher beds (extending up to about 220 m above the base of the formation, according to Whitham, 1993) crop out inland, in the northernmost part of the Yorkshire Wolds, near Driffield. Even higher beds occur beneath drift in the Holderness region where the formation, in boreholes, appears to total about 265 m thick.

Distribution

Known throughout the Northern Province.

Previous names

'Chalk without Flints' of early Geological Survey maps.
Upper Chalk (pars).

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Santonian to Campanian (*Gonioteuthis quadrata* Zone).

References

Wood and Smith, 1978; Whitham, 1993; Mitchell, 1994.

3.1.2.4 Rowe Chalk Formation

Name

The Rowe Formation was first proposed by Lott and Knox (1994) for flint bearing chalks above the Flamborough Chalk Formation offshore. This term was adopted in Sumbler (1999) and is modified herein to Rowe Chalk Formation.

Type section

Borehole 49/24-1, 635 m to 840 m depth (Offshore, Southern North Sea; see Lott and Knox, (1994).

Reference section

Atwick No 2 (1973) borehole (TA 15 SE/9) [TA 1835 5171], from about 41 m to about 122 m.

Formal subdivision

None

Lithology

White, flint-bearing chalk with sporadic marl bands.

Definition of upper boundary

Unconformably overlain by Quaternary deposits onshore: offshore apparently conformably succeeded by Palaeogene deposits (Lott and Knox, 1994).

Definition of lower boundary

Basal flint band of thick unit of flint bearing chalk above thick flint-free unit of Flamborough Chalk Formation; recognised on the basis of downhole geophysical logs.

Thickness

About 80 m preserved onshore; up to about 380 m offshore.

Previous names

Not previously named onshore, thus implicitly included in Flamborough Chalk Formation.

Parent

Chalk Group

Age and biostratigraphy

Upper Cretaceous, Campanian (*Belemnitella mucronata* Zone) onshore, extending into Maastrichtian offshore.

References

Sumbler, 1996, 1999; Lott and Knox, 1994.

4 Scotland Chalk nomenclature (Scottish Chalk Province)

Judd (1878) (Figure 7, Column 1) proposed the first comprehensive lithostratigraphy for the Cretaceous of western Scotland in the third of his extensive papers on the strata of the western coast and islands. Whilst recognising that there were 'very rapid and remarkable changes in thickness and character' he divided the widely spaced successions into four members (numbered I to IV down sequence) representing two marine and estuarine phases of sedimentation. The members in ascending order were Glauconitic Greensand (IV), White Sandstone or Lower Estuarine Series (III), Chalk with bands of flint or Upper Chalk (II) and Sandstones with white marls or Upper Estuarine Series (I). He considered Member IV to be unequivocally of Cenomanian (or mistakenly equivalent to the Upper Greensand) age, Member II contained *Belemnitella mucronata* and was equivalent to the greater part of the White Limestone of Ireland, thus placing his White sandstone or 'Lower Estuarine series' (III) as the equivalent to the whole or part of the Chalk of England. He tentatively placed his sandstones and white marls or 'Upper Estuarine series' (I) in the Cretaceous but suggested that it may well prove to be of younger 'Tertiary' age. His terms of Upper and Lower Estuarine Series are completely different from the Jurassic strata of the same names. He also suggested thicknesses for his members based on the known exposures as follows: VI a maximum of 60 feet (18.3 m), III an average of 100 feet (30.5 m), II a minimum of 10 feet (3.1 m) and I a minimum of 20 feet (6.1 m) (Figure 7).

Subsequent work by Survey officers and others up to the 1920s added to the number of known localities beyond those mentioned by Judd. The principal localities for the Cretaceous of Western Scotland are shown in Figure 8. Much of this work is to be found in the memoirs of the Survey (e.g. Bailey and Anderson, 1925; Lee and Bailey, 1925) and other papers (see Bailey, 1924; Scott, 1928) (Figure 7, Column 2 and Figure 7, Column 3) where a tripartite sequence was described similar to that of Judd but with the proviso that Judd's highest unit (I) was essentially ignored or regarded as of 'Tertiary' age. This work was summarised briefly in Lee and Pringle (1932) (Figure 7, Column 4) within a synopsis of all of the Mesozoic rocks of Scotland. A variety of slightly different terms were used (some with the informal epithet of member or with a locality descriptor). For example in those memoirs and papers the White Sandstone (III) became closely associated with the Loch Aline locality thus creating the term Loch Aline White Sandstone or Glass Sand (this latter term being used because of the rock's exceptional purity and its use in the optical industry). Humphries (1961) comprehensively described the White Sandstone of Loch Aline.

Rawson et al., (1978) (Figure 7, Column 5) introduced the formal term of Morvern Greensand Formation, and so implied that the overlying Loch Aline Glass Sand was also of formational level. The beds above the Loch Aline Glass Sand Formation were unnamed units of 'chalk and greensand' and 'chalk'.

Braley (1990) described the Cretaceous rocks of north-west Scotland and developed the formal terminology, down to member level, outlined in Lowden, et al., (1992) and in Figure 7, Column 6 herein. She introduced the term Inner Hebrides Group to cover all of the Cretaceous beds, and the thin Paleocene(?) sediments, beneath the basalts in the region. However, there are serious problems with the dating of the various units within the sequence.

Hancock (2000) introduced the term Gribun Conglomerate Formation to cover the highest beds, of Maastrichtian(?) age, in the Gribun section on the Isle of Mull. This should not be confused with the Gribun Chalk Formation (Lowden et al., 1992) which they determined to be of Turonian(?) age. Emeleus (1997) used part of this scheme to describe the rocks encountered on Eigg, including the Laig Gorge Beds of Hudson (1960).

Most recently the succession of Cretaceous rocks in the Inner Hebrides Group, at SSSI and other sites in the north-west of Scotland has been the subject of review as part of the Geological Conservation Review (GCR) Series funded by the Joint Nature Conservation Committee. The GCR volume, the British Upper Cretaceous Stratigraphy (Mortimore, et al., 2001), (Figure 7, Column 7) gives a comprehensive account of the sequence, formalises the nomenclature, partly in accordance with Braley (1990) but makes significant changes to the chronology, and corrects earlier correlations. It goes further and suggests correlation with the sequences exposed in Northern Ireland. This document is considered as the standard for the Inner Hebrides Group (see Figure 7). Recommended lithostratigraphical units are listed in Table 4.

Table 4 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of Scotland.

Name of unit	Lexicon code	Map symbol
Black Band Member	None	None
Inner Hebrides Group	None	None
Morvern Greensand Formation	MORG	MorG
Lochaline White Sandstone Formation	LAWS	None
Coire Riabhach Phosphatic Formation	None	None
Gribun Chalk Formation	GRIB	UCG
Feorlin Sandstone Formation	None	None
Strathaird Limestone Formation	STRL	None
Laig Gorge Sandstone Member	None	None
Laig Gorge Limestone Member	LAGL	LagL
Clach Alasdair Conglomerate Member	None	None
Beinn Iadain Mudstone Formation	None	None

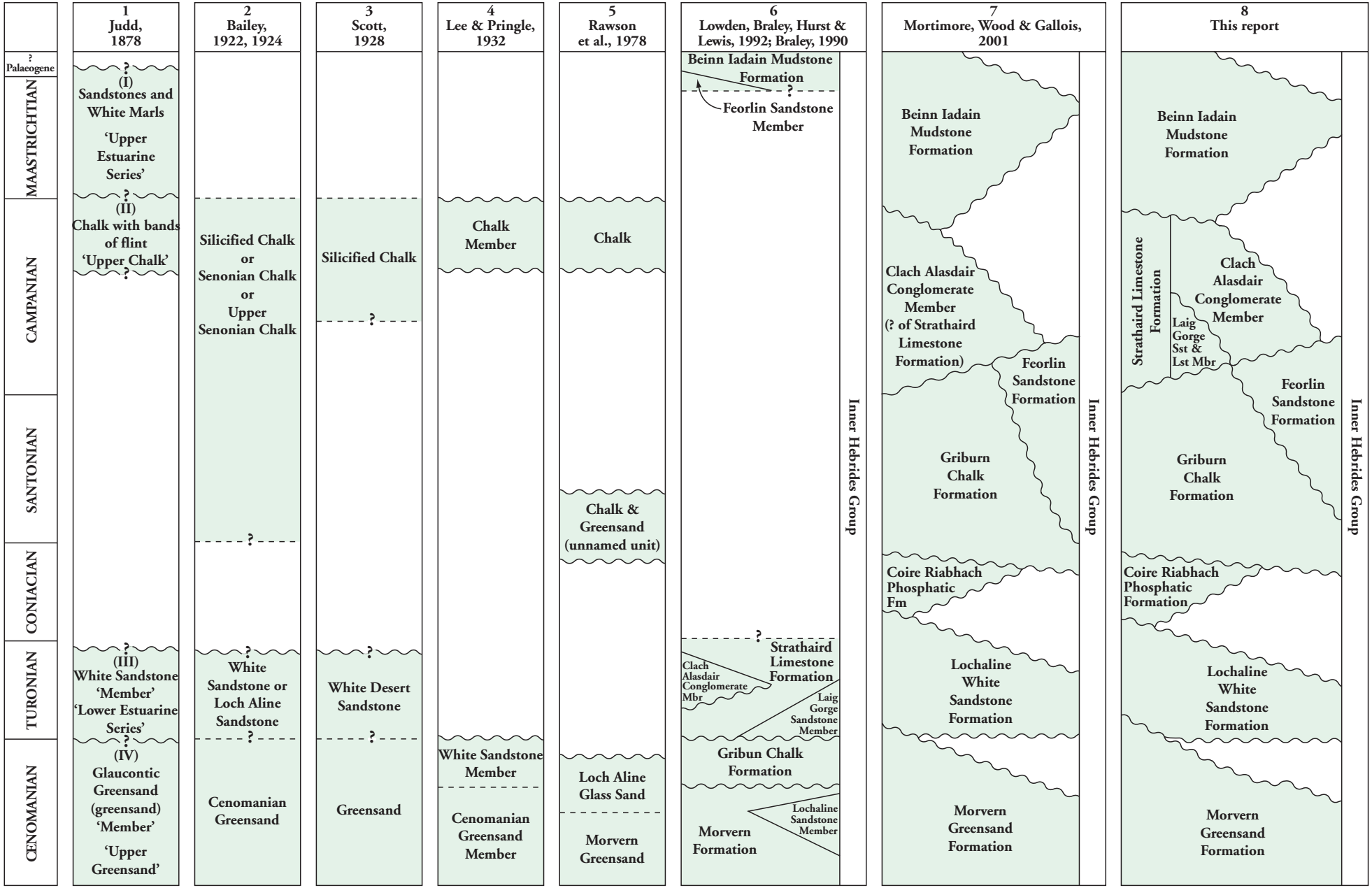


Figure 7 The development of the terminology in the Scottish Chalk Province.

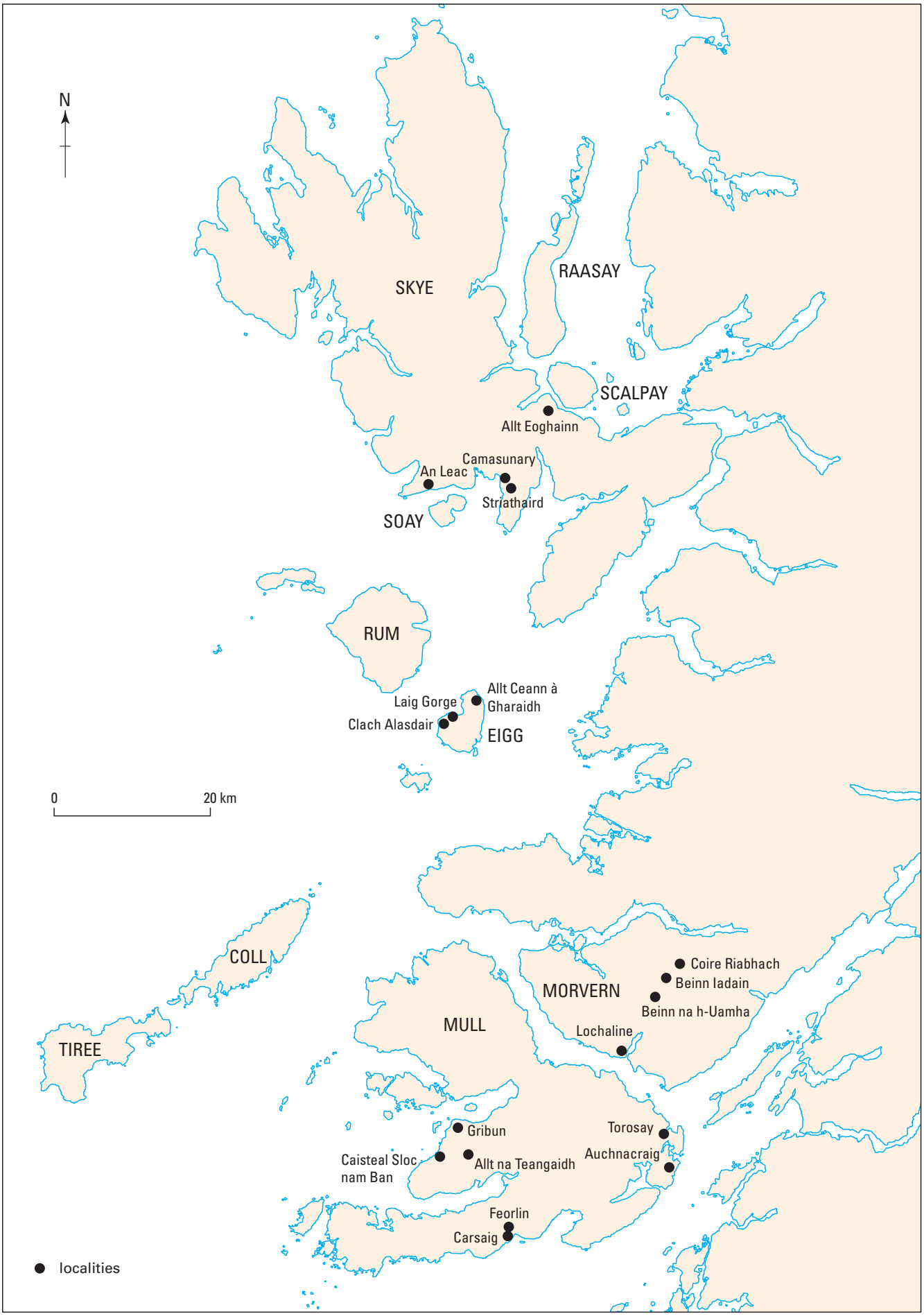


Figure 8 The Inner Hebrides Scottish Chalk Province.

These entries are formalised following the review of Upper Cretaceous nomenclature in Mortimore, Wood and Gallois (2001) that provides the most up-to-date and comprehensive study of these rocks following on from the work of Braley (1990). The equivalent terms used in BGS products are also shown. With the limited and widely spaced outcrops it is inevitable that there is still some debate as to the exact correlation of each of the condensed successions known and indeed the prospect of further successions coming to light that will alter our understanding cannot be discounted. Whilst the Cenomanian age for the basal beds is firmly established, the sparse fauna and degree of reworking can only suggest that Turonian, Santonian and Campanian sedimentary rocks remain. Depositional environments can be difficult to establish and it is by no means certain that a single basin with related sediments can be demonstrated. This problem is of course compounded by the degree of diagenesis suffered by the succession beneath the thick Paleocene basalt cover.

4.1 INNER HEBRIDES GROUP

Name

The Inner Hebrides Group was formally proposed by Braley (1990). See also Lowden, Braley, Hurst, and Lewis, (1992) and Mortimore, Wood, and Gallois, (2001) in which volume a number of the correlations in the earlier work are adjusted and the dating of the sequence refined.

Type section

At various localities for the constituent formations in the Inner Hebrides and Morvern. Principal exposures are at Beinn Iadain and Loch Aline Mine in Morvern, at Gribun, Carsaig and Auchnacraig on Mull, at Clach Alasdair and Laig Gorge on Eigg and Strathaird on Skye.

Primary reference section

At the type sites of the constituent formations and members.

Formal subdivisions

Divided into seven formations and a number of constituent members. These are from the oldest: the Morvern Greensand Formation; Lochaline White Sandstone Formation; Coire Riabhach Phosphatic Formation; Gribun Chalk Formation; Feorlin Sandstone Formation; Strathaird Limestone Formation (including the Clach Alasdair Conglomerate Member and Laig Gorge Sandstone Member) and the Beinn Iadain Mudstone Formation. This latter probably principally of basal Palaeogene in age. A description is included herein for completeness.

Lithology

Glauconitic sandstones, pure silica sands, silicified chalks, flints and conglomerates.

Definition of upper boundary

Unconformable beneath the Paleocene lavas or conformable (?) beneath the Beinn Iadain Mudstone Formation of presumed Paleocene age.

Definition of lower boundary

Unconformable at the erosion surface below the Morvern Greensand Formation.

Thickness

The group comprises a highly condensed sequence and is variable in thickness depending on the relative development of its constituent parts. The group may be as little as a few metres thick but is between 10 to 15 m on Mull and between 11 to 22 m in Morvern.

Distribution

Known from the Inner Hebrides islands of Mull, Eigg, Skye, Scalpay, Soay and Raasay and also from the Morvern district of the Scottish mainland.

Previous names

Generally the Cretaceous rocks of the Inner Hebrides have been described using that title or, because of their limited outcrop, as individual constituent units attached to a locality i.e. Morvern Greensand. Some of these gained greater acceptance and were applied more widely.

Parent

None

Age and biostratigraphy

Upper Cretaceous, Cenomanian to early Campanian.

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001.

4.1.1 Morvern Greensand Formation

Name

In older literature known as the Cenomanian Greensand, Greensand and Cenomanian Greensand Member. Designated the Morvern Greensand in Rawson et al., (1978) and given formation status in Braley (1990).

Type section

In Braley (1990) are two sections given on Beinn Iadain as [NM 6917 5490 and NM 6965 5645] the former presumed to be the section described in Judd (1878) and Lee and Bailey (1925). Mortimore et al., (2001) give their locality as Beinn Iadain, Morvern [NM 670 541 to NM 689 528] and also a site called Beinn na H-Uamha at [NM 68].

Primary reference section

Loch Aline Borehole No. 10 [NM 6890 4695] and Auchnacraig Cliff [NM 7440 2989] in Braley (1990) and Alt na Teangaigh [NM 453 328], Isle of Mull, Mortimore et al., (2001).

Formal subdivision

None

Lithology

Glauconitic calcareous sandstone, white to pale greenish. Some gritty beds and calcareous inclusions up to cobble size. Conspicuously shelly (mainly oysters) in parts.

Definition of upper boundary

Conformable with the Lochaline White Sandstone Formation. However Braley (1990) and Lowden et al., (1992) regarded the Lochaline White Sandstone Formation as a member within this formation and considered the upper boundary as unconformable with the Gribun Chalk Formation.

Definition of lower boundary

Unconformable on various Jurassic and Triassic strata.

Thickness

From 0.3 to 13.4 m in Rawson et al., (1978).

Distribution

Known from the Morvern district and the Isle of Mull.

Previous/equivalent names

Greensand in the literature. Cenomanian Greensand (map code of h or h5) as on Ardnamurchan 52W, Strontian 52E, Iona 43, Mull 44. Glauconitic Sandstone (? Greensand) (map code of GSM or MorG) as on Staffa 43N, Ross of Mull 43S. Greensand of Morvern obsolete Dic_Strat entry (code of GSM). Morvern Greensand (h5) as on Eastern Mull 44W, Lismore 44E and in general informal use in the literature.

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian

References

Rawson et al., 1978; Lee and Pringle, 1932; Braley (1990); Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001.

4.1.2 Lochaline White Sandstone Formation

Name

The Loch Aline Glass Sand of Rawson et al., (1978) and the Lochaline Sandstone Member in Braley (1990). The formation as named above proposed by Mortimore et al., (2001).

Type section

Lochaline Mine adit section [NM 6800 4535], Morvern.

Primary reference section

Loch Aline three sections given in Braley (1990) at waterfalls around the loch [NM 6935 4595, NM 6869 4665, NM 6935 4535], Beinn Iadain [NM 6917 5490 and NM 6965 5645] all in the Morvern district. At various sites in Mull e.g. Auchnacraig Cliff [NM 7440 2989] in Braley (1990) and Alt na Teangaigh [NM 453 328] in Mortimore et al., (2001).

Formal subdivision

None

Lithology

Very pure white to pale yellow brown well-sorted medium-grained quartz sandstone. Massive with laminated and shelly beds to base. Most comprehensively described by Humphries (1961) at its type site.

Definition of upper boundary

Unconformable beneath the Gribun Chalk Formation or Coire Riabhach Phosphatic Formation.

Definition of lower boundary

Conformable (?) on the Morvern Greensand Formation.

Thickness

Up to 40 feet (12.2 m) on the west side of Loch Aline according to Humphries (1961).

Distribution

Known from the Morvern district and the Isle of Mull.

Previous/equivalent names

Loch Aline Glass Sand (Loch Aline) (map code of h5') as on Lismore 44E, Eastern Mull 44W. White Sandstone (map code of h5') as on Iona 43. White Sandstone (?Loch Aline Glass Sand) (map code of LAWS) as on Staffa 43N. Loch Aline White Sandstone.

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian; Turonian to Santonian in Mortimore et al., (2001).

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001. (In this volume a number of the correlations in the earlier works are adjusted and the dating of the sequence refined. The term Lochaline White Sandstone Formation appears first in this volume as one of the adjustments to the terminology and correlation of the sequence of Braley, 1990).

4.1.3 Coire Riabhach Phosphatic Formation

Name

The name first appears in Mortimore et al., (2001) and is substantially unrecognised in previous descriptions.

Type section

Stream section on the west bank of Coire Riabhach [NM 697 564] on the north-east flank of Beinn Iadain.

Primary reference section

As above

Formal subdivision

None

Lithology

Up to five beds of glauconitic sand with phosphate nodules and fossil casts.

Definition of upper boundary

Unconformable (or a non-sequence at an erosion surface) with the overlying Gribun Chalk Formation.

Definition of lower boundary

Conformable (or a non-sequence at an erosion surface) with the underlying Lochaline White Sandstone Formation.

Thickness

Usually less than one metre.

Distribution

Limited to the Beinn Iadain area.

Previous names

None

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous, Coniacian to Santonian in Mortimore et al., (2001).

References

Mortimore, Wood and Gallois, 2001. (In this volume a number of the correlations in the earlier works are adjusted and the dating of the sequence refined. The term Coire Riabhach Phosphatic Formation appears first in this volume as one of the adjustments to the terminology and correlation of the sequence proposed by Braley, 1990).

Note

Because of its relative thinness it is questionable as to whether this bed is a 'mappable' unit and as such worthy of formational status, however it is prominent in sections logged in Morvern and may prove the correlative of the basal unit of the Gribun Chalk Formation as mapped on Mull where glauconite is seen in the sequences associated with erosional surfaces. It may also be a key link with the Northern Ireland succession where Mortimore et al., correlate it with the Cloghfin Sponge Formation at the base of the Ulster White Limestone Group.

4.1.4 Gribun Chalk Formation

Name

The Gribun Chalk Formation was formally proposed by Braley (1990).

Type section

The Gribun Boulder [NM 457 357] and Gribun Stream Boulder [NM 456 355], Isle of Mull.

Primary reference section

Clachandhu Boulders [NM 4550 3533, NM 4550 3531, NM 4550 3528] and at Allt na Teangaidh [NM 453 328] near Gribun, Isle of Mull.

Formal subdivision

None

Lithology

Silicified Chalk. Reworked Chalk and conglomerate as (?) debris flow. Flinty in part.

Definition of upper boundary

Unconformable with the Clach Alasdair Conglomerate Member of the Strathaird Limestone Formation or Beinn Iadain Mudstone Formation (basal Paleocene age).

Definition of lower boundary

Unconformable on the Coire Riabhach Phosphatic Formation or the Lochaline White Sandstone Formation.

Thickness

About 5 m at Gribun, about 1 m elsewhere.

Distribution

Principally on the island of Mull and within the Morvern district.

Previous/equivalent names

-

Note

Hancock (2000), confusingly, used the term Gribun Formation or Gribun Conglomerate Formation to describe rocks above the Chalk (silicified Chalk) of? Santonian age which is the named Gribun Chalk Formation. This unit is probably equivalent to the Clach Alasdair Conglomerate Member of Mortimore, Woods and Gallois (2001).

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian in Lowden et al., (1992); Santonian in Hancock, (2000); Santonian to Campanian in Mortimore et al., (2001).

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001.

4.1.5 Strathaird Limestone Formation

Name

The Strathaird Limestone Formation was formally proposed by Braley (1990).

Type section

Strathaird [NG 5365 1790], Skye.

Primary reference section

Laig Gorge [NM 4735 8750] on Eigg, Camasunary [NG 5181 1775], and two sections at Allt Eoghainn, Strollamus [NG 5965 2645] on Skye, An Leac headland, Soay Sound [NG 4400 1695], and numerous localities of the Clach Alasdair Conglomerate Member on Mull.

Formal subdivision

Includes the Clach Alasdair Conglomerate Member and the Laig Gorge Sandstone Member.

Lithology

Dark grey micritic limestone and two clastic members. A basal Laig Gorge Sandstone member and the Clach Alasdair Conglomerate Member.

Definition of upper boundary

Unconformable below the Beinn Iadain Mudstone Formation or at an erosion surface beneath the Palaeogene basalts.

Definition of lower boundary

Unconformable upon the Gribun Chalk Formation and Feorlin Sandstone Formation.

Thickness

From 2 to 6 m on Eigg, 2.5 m on Skye and 2 m of the Clach Alasdair Conglomerate Member on Mull.

Distribution

Throughout the Inner Hebrides islands but poorly represented in Morvern.

Previous names

Part of the Silicified Chalk and its derivative names in earlier accounts.

Note

Hancock (2000), confusingly, used the term Gribun Formation or Gribun Conglomerate Formation to describe

rocks above the Chalk (silicified Chalk) of? Santonian age which is the named Gribun Chalk Formation. This unit is probably equivalent to the Strathaird Limestone Formation (in part) of Braley (1990) or the Clach Alasdair Conglomerate Member of Mortimore, Woods and Gallois (2001). Probably the same beds as Hancock's (2000) Gribun Chalk. Probably equivalent to the Laig Gorge Limestone Member (LAGL) as mapped on the Rum Sheet 60 where Braley (1990) uses the name Strathaird Limestone Formation.

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous, Turonian.

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992.
This Formation is not mentioned in Mortimore, Wood and Gallois (2001) although the Clach Alasdair Conglomerate Member is used for the beds intervening between the Gribun Chalk Formation and the Ben Iadain Mudstone Formation.

4.1.5.1 Clach Alasdair Conglomerate Member

Name

The Clach Alasdair Conglomerate Member was formally proposed by Braley (1990).

Type section

Clach Alasdair [NM 4540 8831], Eigg.

Primary reference section

Caisteal Sloc nam Ban [NM 431 312] in the Wilderness and Allt na Teangaidh [NM 453 328] on Mull. Strathaird [NG 5365 1790] on Skye.

Formal subdivision

None

Lithology

Conglomerate (principally silicified chalk clasts) with a coarse sandstone matrix.

Definition of upper boundary

Top of member not seen at the type site at Clach Alasdair on Eigg nor at Strathaird on Skye. May be unconformable beneath the Ben Iadain Mudstone Formation at Gribun, Allt na Teangaidh, Mull (Mortimore, Wood and Gallois, 2001).

Definition of lower boundary

Unconformable on beds attributed to the Morvern Greensand at the Clach Alasdair type site on Eigg (Braley, 1990), and unconformable on the Strathaird Limestone Formation at the type site of that unit on Skye. Considered to rest on the Gribun Chalk Formation elsewhere according to Mortimore, Wood and Gallois (2001).

Thickness

Only 0.5 m at Strathaird and 0.4 m at Clach Alasdair in Braley (1990) and up to 2.5 m at Caisteal Sloc nam Ban, Mull in Mortimore, Wood and Gallois (2001).

Distribution

Known throughout the Inner Hebrides Eigg, Skye and Mull and in Morvern.

Previous names

None

Parent

Strathaird Limestone Formation.

Age and biostratigraphy

Upper Cretaceous, Turonian, but considered to be Campanian in age by Mortimore, Wood and Gallois (2001).

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001. In this volume a number of the correlations in the earlier works are adjusted and the dating of the sequence refined.

4.1.5.2 Laig Gorge Sandstone Member

Name

The Laig Gorge Sandstone Member was formally proposed by Braley (1990).

Type section

Laig Gorge [NM 4735 8750] on Eigg.

Primary reference section

Strathaird [NG 5365 1790] on Skye.

Formal subdivision

None

Lithology

Medium- to coarse-grained poorly sorted sandstones and conglomerates.

Definition of upper boundary

Unconformable at an erosion surface above a coarse very poorly sorted conglomerate with the grey micritic limestones of the remainder of the Strathaird Limestone Formation at Strathaird on Skye but apparently conformable at a burrowed horizon with the same limestones at Laig Gorge on Eigg.

Definition of lower boundary

Unconformable on the Gribun Chalk Formation but considered absent in Mull and Morvern by Mortimore, Wood and Gallois (2001). This is the basal unit of the Strathaird Limestone Formation according to Braley (1990).

Thickness

Measures 3.0 m at Laig Gorge, Eigg.

Distribution

Known on the islands of Eigg and Skye.

Previous names

None

Parent

Strathaird Limestone Formation.

Age and biostratigraphy

Upper Cretaceous, Turonian.

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001. In this volume a

number of the correlations in the earlier works are adjusted and the dating of the sequence refined. The member is not considered to be in the sequences on Mull or Morvern.

4.1.6 Feorlin Sandstone Formation

Name

The Feorlin Sandstone Formation was formally proposed by Braley (1990) as part of the Beinn Iadain Mudstone Formation but is considered as a formation in its own right beneath the Beinn Iadain Mudstone Formation and questionably beneath the Clach Alasdair Conglomerate Member by Mortimore et al., (2001).

Type section

Feorlin Cottage [NM 5317 2225] at Carsaig, Mull.

Primary reference section

Caisteal Sloc nam Ban [NM 431 312] in the Wilderness on Mull.

Formal subdivision

None

Lithology

Slightly glauconitic sandstone with silicified chalk pebbles.

Definition of upper boundary

Conformable with the rest of the Ben Iadain Mudstone Formation (Braley, 1990) or questionably beneath the Clach Alasdair Conglomerate Member (Mortimore, Wood and Gallois, 2001).

Definition of lower boundary

Unconformable on the Strathaird Limestone Formation when considered as the basal member of the Ben Iadain Mudstone Formation (Braley, 1990), or on the Gribun Chalk Formation or Morvern Greensand (Mortimore, Wood and Gallois, 2001) as a formation in its own right.

Thickness

About 8.5 m is attributed to these beds at Caisteal Sloc nam Ban in the Wilderness on Mull.

Distribution

Known from the island of Mull.

Previous names

None

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous or Paleocene.

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001. In this volume a number of the correlations in the earlier works are adjusted and the dating of the sequence refined. The name is given formational status in the successions on Mull.

Note

The Feorlin Sandstone Formation of Mortimore, Wood and Gallois (2001) is considered to be a formation in its own right and forming part of the Upper Cretaceous sequence (or possibly Paleocene). At the Caisteal Sloc nam Ban section on the Isle of Mull the formation is shown beneath the Clach Alasdair Conglomerate Member (which elsewhere in Mortimore et al., (2001) is shown as Santonian to Maastrichtian in age) itself within the Strathaird Limestone Formation. Braley (1990) considers the unit to be a member within the Ben Iadain Mudstone Formation of Paleocene or younger age.

4.1.7 Beinn Iadain Mudstone Formation

Name

The Beinn Iadain Mudstone Formation was formally proposed by Braley (1990).

Type section

Beinn Iadain Section A of Braley (1990) [NM 6917 5490] in Morvern.

Primary reference section

Allt na Teangaidh [NM 453 328] on Mull.

Formal subdivision

Considered by Braley (1990) to include the Feorlin Sandstone Member.

Lithology

Mudstone and siltstone, shaly and micaceous, red to purplish in colour but bleached white in places considered to be 'argillised ash' by Mortimore et al., (2001). Organic rich and sandy in lower part.

Definition of upper boundary

Disconformable at a sharp contact beneath Paleocene lavas.

Definition of lower boundary

Unconformable above an erosive contact with underlying conglomerates of the Clach Alasdair Conglomerate Member.

Thickness

Some 2.5 m at Allt na Teangaidh on Mull, about 1.9 m at Feorlin tributary section [NM 5317 2225], 0.92 m at the type site on Beinn Iadain.

Distribution

Known from Morvern and the island of Mull.

Previous names

Considered by Braley (1990) to be equivalent to the 'Upper Estuarine Series' of Judd (1878).

Parent

Inner Hebrides Group.

Age and biostratigraphy

Upper Cretaceous or Paleocene.

References

Braley, 1990; Lowden, Braley, Hurst and Lewis, 1992; Mortimore, Wood and Gallois, 2001. In this volume a number of the correlations in the earlier works are adjusted and the dating of the sequence refined. The name is given formational status in the sequences on Mull.

5 Statement on Northern Ireland Chalk nomenclature (Ulster Cretaceous Province)

The classification of Cretaceous rocks in Northern Ireland dates from 1786 when Whitehurst (1786) made comments on the outcrop using the term 'White Limestone'. Sampson (1814) demonstrated that this White Limestone was underlain by a succession of greensands, conglomerates and marls. Essentially, these workers established the two-fold division of the Cretaceous.

Portlock (1843) suggested three divisions of the strata introducing the terms Upper Chalk (equivalent to the White Limestone), an intermediate unit the Lower Chalk (Glauconitic Chalk) and a lower unit termed the Greensands. Bryce (1853) divided the 'greensands' into three, and this three-fold division was also recognised by Tate (1865) (Figure 9, Column 1). The work of Tate was the first appraisal of the faunal and lithological characteristics of the full Cretaceous sequence and its comparison to the English and French schemes. In his appraisal of the biozones present he recognised that most of the Middle Chalk of England was unrepresented in Northern Ireland and reverted to a two-fold division of the strata into the 'Hibernian Greensand' and 'Upper Chalk' formations. Further division equivalent to 'member' status formalised the terms, in ascending order, of Glauconitic Sands, 'Grey Marls and Yellow Sandstones with Chert', 'Chloritic Sands and Sandstones', as subdivisions of the Hibernian Greensand; and the 'Chloritic Chalk' and 'White Limestone' (or 'Hard Chalk') as subdivisions of the Upper Chalk (Figure 9).

Gault (1878) and Hume (1897) (Figure 9/2) added refinements and corrections to the work of Tate based on more extensive fieldwork. Hume (1897) produced a comprehensive description and correlation for the whole of Northern Ireland and divided the outcrop into five geographical 'divisions' each with its own character, thus essentially being the first to recognise the structural control on sedimentation in the Province. He also suggested the term 'Antrim Beds', in his 'eastern division', for the Chloritic Sands (sensu Tate). Reid (1958) introduced the terms 'Upper Glauconitic Sandstone' and 'Lower Glauconitic Sandstone' to cover Hume's Antrim Beds and the older Zone of *Exogyra columba*, thus separating the Cenomanian (Lower) from the ?late Turonian and Senonian (Upper) strata. The outcrop and principal localities of the Ulster Cretaceous are shown in Figure 10.

Hancock (1961) (Figure 9, Column 3) made a complete re-assessment of the Cretaceous of north-east Ireland. He attempted to simplify terminology and included Tate's and Hume's Chloritic Sands and Chloritic Chalk in his 'Upper Glauconitic Beds' of the 'Hibernian Greensands'. In so doing Hancock amalgamated the glauconite rich beds of post-Cenomanian age despite there being a second major diachronous break within the succession. Hancock's Hibernian Greensands 'Formation' also included the 'Yellow Sandstone' and 'Glauconite Sands' each respectively equivalent to the Grey Marls and Yellow Sandstones and the Glauconitic Sands of Tate and Hume.

Extensive work by staff of the Geological Survey (Wilson and Robbie, 1966; Manning et al., 1970; Fowler and Robbie, 1961) led to a significant systematic reappraisal of the Cretaceous of Northern Ireland. The Belfast memoir (Manning et al., 1970) (Figure 9, Column 4) offers the fullest account and maintained the White Limestone and Hibernian Greensand divisions. They further divided the Hibernian Greensand into 'Cenomanian Greensands' (equivalent to the Yellow Sandstones and Grey Marls, and Glauconitic Sands of previous authors), the 'Cenomanian/Turonian Greensands' (including the new terms of 'Glauconitic Sands and Sandstones' and 'Quartzose Sand') and the 'Senonian Greensands' (presumably equivalent to the Upper Glauconitic Beds of Hancock, 1961). The White Limestone was divided, in ascending order, into a basal 'Conglomerate Bed', 'Chalk with derived Glauconite', 'Lower White Limestone' and an 'Upper White Limestone' (this latter being subdivided into four named beds).

Reid (1971) (Figure 9, Column 5) summarised the earlier papers and gave an indication of the spatial variability of the Cretaceous succession across the Province in his Figure 2. Fletcher (1977) (Figure 9, Column 6) introduced a comprehensive nomenclature for the Cretaceous of northeast Ireland and formalised the terms of the 'Hibernian Greensands Formation' and the 'Ulster White Limestone Formation'. The Hibernian Greensands Formation was redefined with respect to the proposals by Tate (1865) and Hancock (1961) and he confined the term to the glauconitic sands and related clastic deposits. He excluded the 'Glauconitic Chalk' from the formation regarding this as a local, structurally controlled, facies of a number of his Ulster White Limestone Formation members.

Fletcher (1977) divided the Ulster White Limestone Formation into fourteen members on the basis of their lithological character, correlation of marker bands and their spatial distribution (see Fletcher, 1977; Fig.8). His work is the standard for the succession mapped in Northern Ireland and is used on the subsequent map publications on the geology of the Province.

Griffith and Wilson (1982) (Figure 9, Column 7) gave formal names to the 'members' of the Hibernian Greensands first defined but unnamed by Fletcher (1977).

There is an argument for upgrading Fletcher's system, elevating his members to formations permitting the introduction, in future years, of chalk and glauconitic chalk members within each of his presently constituted members. In so doing the Ulster White Limestone and Hibernian Greensands would then be considered as groups or subgroups depending on whether it was felt that an over-arching group term should be applied to the Cretaceous of the province. The use of the term Chalk Group (in the sense of its use in England and the North Sea) would provide uniformity to the Upper Cretaceous of the whole of the UK but may not be appropriate because of the distinct clastic nature of the lower half of the succession. It is recommended herein that the terms Hibernian Group and Ulster White Limestone Group be introduced with Fletcher's member being elevated to formation status.

Within the lexicon there are only full formal descriptions for the two formations (now groups), each of the members (formations) are registered as code only. In consequence an

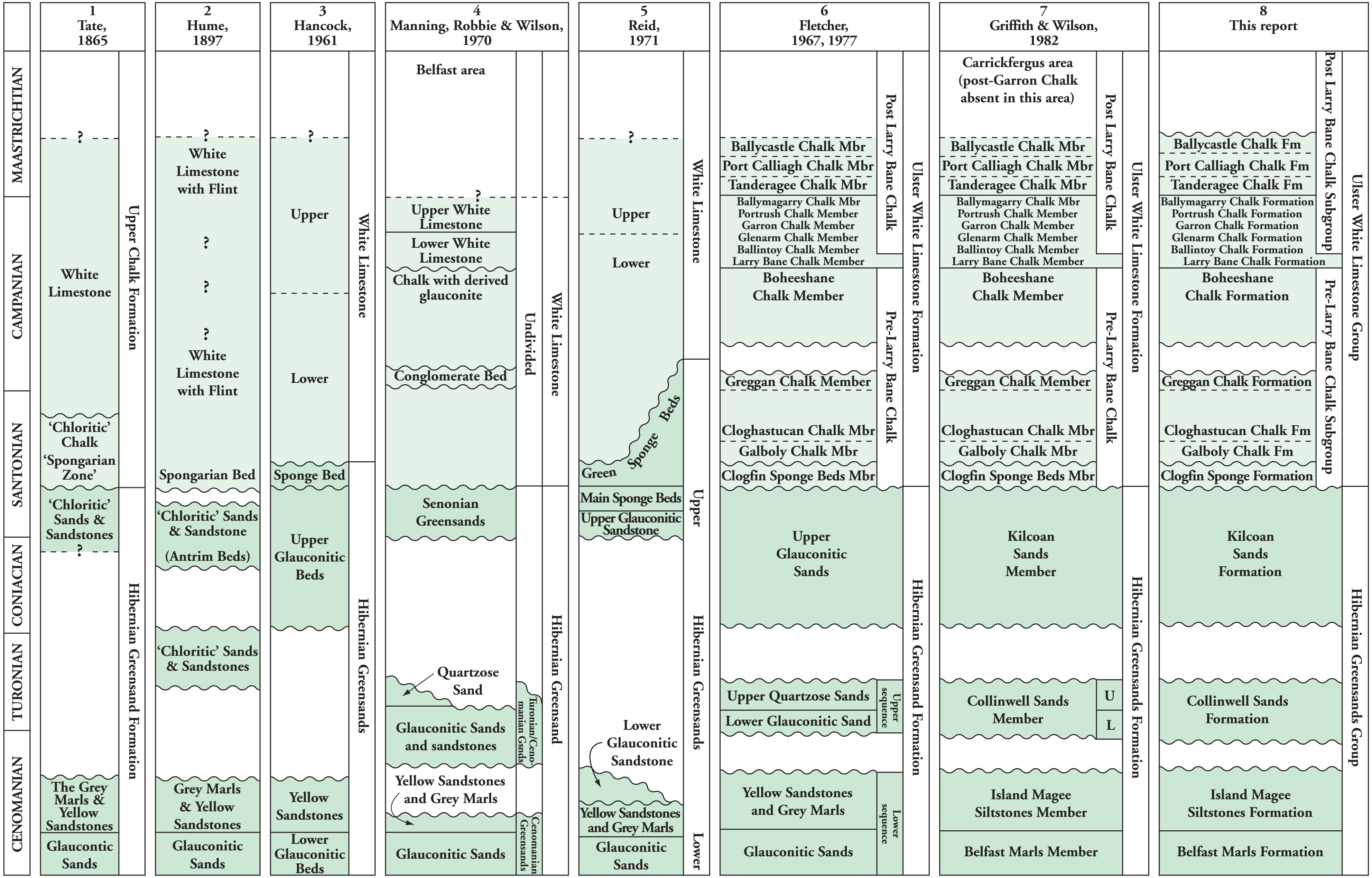


Figure 9 The development of the terminology in the Ulster Cretaceous Province.

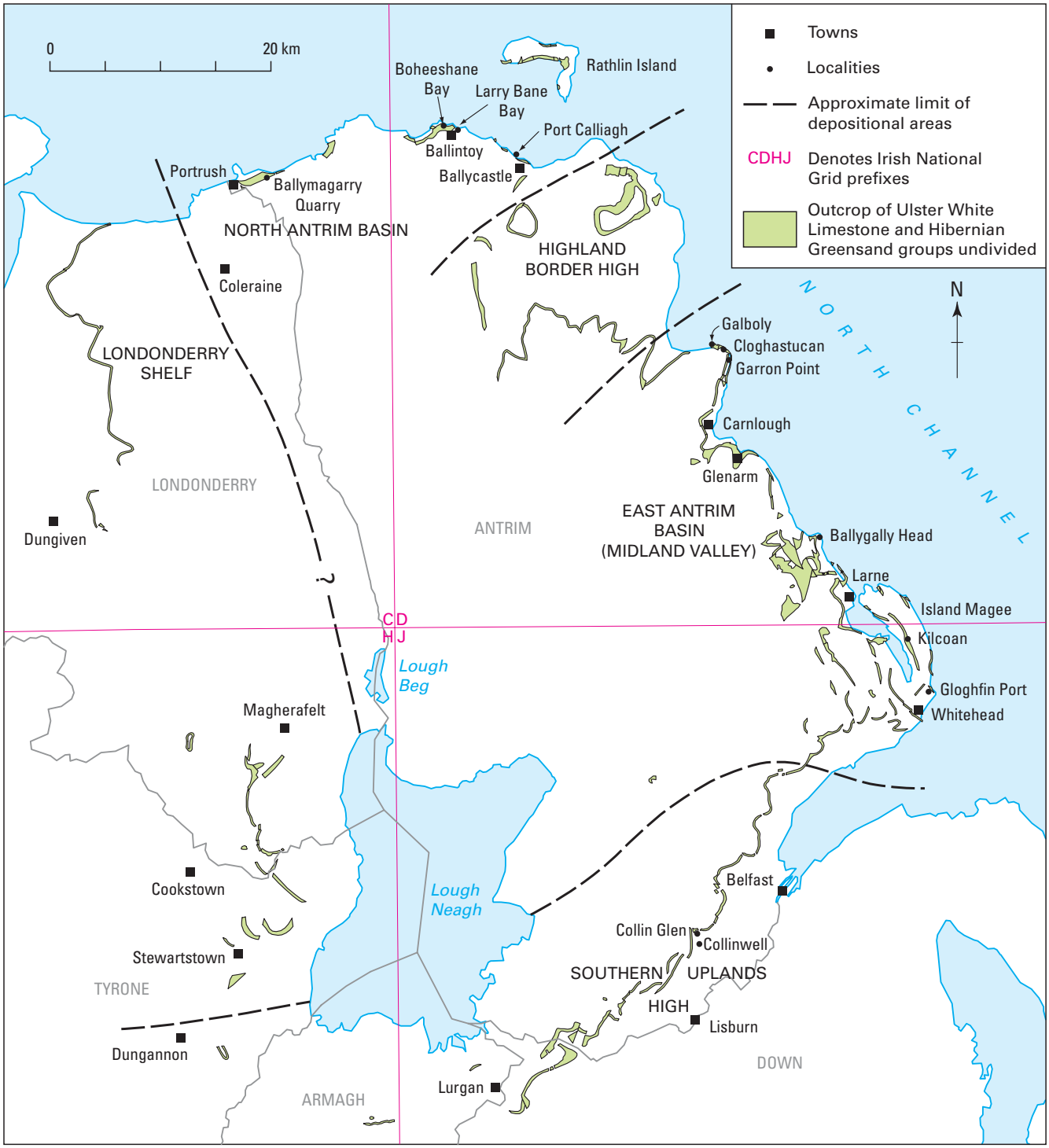


Figure 10 The Northern Ireland Cretaceous Province.

attempt has been made to outline the main Lexicon entry-style information for each of Fletcher's units below. The lithostatigraphical units used on maps and memoirs are listed in Table 5.

Prior to this report there was no formal 'group' level nomenclature for the Northern Ireland succession. The term Chalk Group could be utilised to cover all of the deposits of the Upper Cretaceous in the Province despite the lower part of the sequence being predominantly in 'greensand facies'. However it may prove preferable, and suggested herein, to raise the status of each of the presently defined formation and member level entries to group and formation respectively. In so doing formalising the framework and permitting greater flexibility to future workers on the succession at the member level.

5.1 HIBERNIAN GREENSANDS GROUP

(See note above concerning the adoption of Hibernian Greensand Group as the formal notation for this succession of units).

Name

The name was first proposed by Tate (1865) as Hibernian Greensand. Hancock (1961) used the term Hibernian Greensands. Hibernian Greensands Formation was adopted

Table 5 The lithostratigraphical units used on the 1:50 000 geological maps and within the descriptive memoirs of Northern Ireland.

Name of unit	Lexicon code	Map symbol
Ballintoy Chalk Formation	BTC	None
Ballycastle Chalk formation	BCCK	None
Ballymagarry Chalk Formation	BMC	None
Belfast Marls Formation	BLFM	None
Boheeshane Chalk Formation	BHCK	None
Cloghastucan Chalk Formation	CLC	None
Cloghfin Sponge Formation	CSP	None
Collinwell Sands Formation	CLLW	None
Creggan Chalk Formation	CGCK	None
Galboly Chalk Formation	GCK	None
Garron Chalk Formation	GRCK	None
Glenarm Chalk formation	GAC	None
Hibernian Greensands Group	HBG	HBG
Island Magee Siltstones Formation	ISMS	None
Kilcoan Sands Formation	KOS	None
Larry Bane Chalk Formation	LBC	None
Portrush Chalk Formation	PRC	None
Port Calliagh Chalk Formation	PCC	None
Post-Larry Bane Chalk Subgroup	None	None
Pre-Larry Bane Chalk Subgroup	None	None
Tanderagee Chalk Formation	TDC	None
Ulster White Limestone Group	UWLF	UWLF

in BGS publications and in Fletcher (1967). Elevated to Group status herein.

Type section

Numerous exposures of the constituent formations (see formal subdivisions below for reference to those divisions) in the Midland (East Antrim) Basin and Southern Uplands district.

Primary reference section

Cloghfin Port [J 483 938], Magheramorne Borehole [J 433 975] and area, Collin Glen [J 269 702] district south-west of Belfast, Kilcoan Old Quarry [J 461 985] on Island Magee.

Formal subdivisions

Divided into four members as in the BGS memoir (e.g. Griffith and Wilson, 1982). It is proposed herein that the group be divided at the formation level in ascending order, the Belfast Marls Formation, the Island Magee Siltstones Formation, the Collinwell Sands Formation and the Kilcoan Sands Formation.

Lithology

Glauconitic 'marls', argillaceous siltstones and calcareous sandstones, and quartzose sands. Succession divided into four formations noted above.

Definition of upper boundary

Unconformable at a major regional erosional break. Overlain by various members of the Ulster White Limestone Group.

Definition of lower boundary

Unconformable on a variety of older formations at a major regional erosinal break at the base of the Belfast Marls Member.

Thickness

About 21 m to 22 m in the Carrickfergus, Larne, Antrim and Belfast sheet areas.

Distribution

Throughout Northern Ireland. As a thin basal Cretaceous unit over structural highs and in the North Antrim Basin, where the group is undivided. Fullest development in the Midland Valley (East Antrim Basin) and the Southern Uplands as defined in Fletcher (1977) where group is divided.

Previous names

'Mulatto' a collective term for the greensands, conglomerates and marls beneath the White Limestone (Whitehurst, 1786); the 'Greensands' of Portlock (1843); Hibernian Greensand of Tate (1865); part of Hibernian Greensands as defined by Hancock (1961); the Upper and Lower Hibernian Greensands of Reid (1971). Hibernian Greensand Formation in BGS publications and Fletcher (1967).

Parent

None

Age and biostratigraphy

Upper Cretaceous, Cenomanian to Santonian. Various basal Upper Cretaceous zones up to *Micraster coranguinum* Zone.

References

Fletcher, 1967, 1977; Griffith and Wilson, 1982.

The following entries, in stratigraphical order from the base, for the formations of the Hibernian Greensands Group form part of the Lexicon derived from its precursor Dic_Strat (as code only entries). They are not shown individually upon maps of Northern Ireland but are described in various publications from the province (see note above concerning the adoption of Hibernian Greensand Group as the formal notation for this succession of beds thus raising the rank of each of the following from member status).

5.1.1 Belfast Marls Formation

Name

The Belfast Marls Member was first used in Griffith and Wilson (1982). The term is upgraded to formation status herein.

Type section

Cloghfin Port area [J 483 938] where three exposures of the formation occur, Woodburn Glen South and 503 m north-west of Knock Lodge.

Primary reference section

Carrs Glen near Belfast [J 311 793], in a borehole near Magheramorne [J 433 975]. Numerous localities on the Larne, Antrim, Carrickfergus and Belfast sheet areas (see Griffith and Wilson, 1982, p.48, fig.16A).

Formal subdivisions

None

Lithology

Pale grey strongly bioturbated silty marls with a scattering of dark green glauconite grains (not exceeding 40%). Transitional 'zone' at the top contains relatively little glauconite. Fossiliferous with concentrations in discreet laterally continuous shell-beds.

Definition of upper boundary

Conformable, junction arbitrarily drawn at the base of the lowest persistent hard calcareous siltstone of the overlying Island Magee Siltstones Formation. This junction appears at the top of a transitional zone showing an upward decrease in glauconite content.

Definition of lower boundary

Unconformable, oversteps various older units.

Thickness

Maximum thickness of a little less than 3.0 m known from a borehole near Magheramorne [J 433 975] in the Larne (Sheet 21) area. Minimum thickness of 1.6 m over the Knockagh Axis north of Belfast.

Distribution

East Antrim Basin and Southern Uplands area of Northern Ireland.

Previous names

Glauconitic Sands of Tate (1865) and subsequent workers. Belfast Marls Member.

Parent

Hibernian Greensand Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to basal *Acanthocerus rhotomagense* Zone.

Reference

Griffith and Wilson, 1982.

5.1.2 Island Magee Siltstones Formation

Name

The Island Magee Siltstones Member was first used in Griffith and Wilson (1982). The term is upgraded to formation status herein.

Type section

Collin Glen [J 269 702] (Belfast area), Cloghfin [J 483 938] (Carrickfergus area), Magheramorne area [J 430 980] (Larne area).

Primary reference section

Kilcoan Old Quarry [J 4610 9850] and numerous localities on the Larne, Antrim, Carrickfergus and Belfast sheet areas (see Griffith and Wilson, 1982, p.48, fig.16A).

Formal subdivisions

None

Definition of upper boundary

Disconformable with the Collinwell Sands Formation and unconformable with the Kilcoan Sands Formation beneath the so-called Turonian non-sequence of the Hibernian Greensands Group.

Definition of lower boundary

Conformable with the Belfast Marls Formation with the boundary arbitrarily taken at the base of the first upwardly occurring hard calcareous siltstone above the transitional top of the preceding formation.

Lithology

Hard and soft grey siltstones and marls (calcareous siltstones) that weather to a pale yellow colour.

Distribution

East Antrim Basin and the Southern Uplands area of Northern Ireland.

Thickness

A maximum of 8.0 m in the Magheramorne area and a minimum of 0.67 m over the Knockagh Axis north of Belfast.

Previous names

The Grey Marls and Yellow Sandstones with Chert of Tate (1865) and Reid (1971); Yellow Sandstones of Hume (1897) and Hancock (1961); Yellow Sandstones and Grey Marls of Manning, Robbie and Wilson (1970). Island Magee Siltstones Member.

Parent

Hibernian Greensands Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Acanthoceras rhotomagense* Zone.

Reference

Griffith and Wilson, 1982.

5.1.3 Collinwell Sands Formation

Name

The Collinwell Sands Member was first used in Griffith and Wilson (1982). The term is upgraded to formation status herein.

Type section

The formation is best developed south-west of Belfast and was described from a type area around Collin Glen [J 269 702] in terms of the old Glauconitic Sands. This site

is reported in Manning, Robbie and Wilson (1970) to be obscured by landslips. The member was named after the quarry at Collinwell [J 269 701] nearby.

Primary reference section

Kilcoan Old Quarry [J 461 985] and numerous localities on the Larne, Antrim, Carrickfergus and Belfast sheet areas (see Griffith and Wilson, 1982, p.48, fig.16A).

Formal subdivisions

None

Lithology

Pale green to grey coarse-grained unconsolidated sands with some glauconite. Becomes whitish and poorly glauconitic in the Carrickfergus district.

Definition of upper boundary

Unconformable at an erosion surface with younger Kilcoan Sands Formation beneath the so-called Turonian non-sequence within the Hibernian Greensands Group; and beneath the erosion surface at the base of the Ulster White Limestone Group.

Definition of lower boundary

Disconformable at an erosional surface upon the Island Magee Siltstones Formation.

Thickness

Maximum of 2.4 m at Rungill Burn in the Carrickfergus district.

Distribution

Fully developed in the area south-west of Belfast within the East Antrim Basin and Southern Uplands area. Elsewhere in Northern Ireland the formation may be represented in the condensed successions of the undivided Hibernian Greensands Group.

Previous names

Part of the Glauconitic Sands of Tate (1865); part of the Chloritic Sands and Sandstones of Hume (1897); lower part ('Basement Sands') of the Upper Glauconitic Beds of Hancock (1961); part of the Lower Hibernian Greensands of Reid (1971); the Quartzose Sand (part of the Cenomanian/Turonian Greensands) of Manning, Robbie and Wilson (1970). Collinwell Sands Member in BGS publications.

Parent

Hibernian Greensands Group.

Age and biostratigraphy

Upper Cretaceous, Uppermost Cenomanian and Turonian. *Rhynchostreon suborbiculatum* Zone.

References

Fletcher, 1967; Griffith and Wilson, 1982.

5.1.4 Kilcoan Sands Formation

Name

The Kilcoan Sands Member was first used in Griffith and Wilson (1982). The term is upgraded to formation status herein.

Type section

The old cutting to the old Kilcoan Quarry [J 4610 9850] west Island Magee.

Primary reference section

Numerous localities on the Larne, Antrim, Carrickfergus and Belfast sheet areas (see Griffith and Wilson, 1982, p.48, fig.16A).

Formal subdivision

None

Lithology

Pale green glauconitic sands thought largely to be derived from the Collinwell Sands Formation. Three conspicuous Inoceramus bands divide the succession into three unequal parts.

Definition of upper boundary

Disconformable at an erosion surface beneath various younger members of the Ulster White Limestone Group.

Definition of lower boundary

Disconformable at an erosion surface above the mid-Hibernian Greensands 'unconformity'. Rests on each of the older formations in the group and overlaps onto pre-Cretaceous strata over the most positive structural highs.

Thickness

Up to 7.3 m at Kilcoan.

Distribution

Fully developed in the Island Magee area and within the East Antrim Basin and Southern Uplands area. Elsewhere in Northern Ireland the formation may be represented in the condensed successions of the undivided Hibernian Greensands Group.

Previous names

Part of the Chloritic Sands and Sandstones of Tate (1865) and Hume (1897); part of the Upper Glauconitic Beds of Hancock (1961); The Upper Hibernian Greensands of Reid (1971); Senonian Greensands of Manning, Robbie and Wilson (1970). Kilcoan Sands Member.

Parent

Hibernian Greensands Group.

Age and biostratigraphy

Coniacian to Santonian. *Micraster cortestudinarium* to *Micraster coranguinum* zones.

References

Fletcher, 1967; Griffith and Wilson, 1982.

5.2 ULSTER WHITE LIMESTONE GROUP

(See note below concerning the adoption of Ulster White Limestone Group as the formal notation for this succession of units)

Name

The White Limestone of Hancock (1961). Ulster White Limestone Formation proposed in Fletcher (1967, 1977). Elevated to group status herein.

Type section

Numerous exposures of the constituent formations (see formal subdivisions below for reference to those divisions) with no one site containing all of the stratigraphical elements included within the group.

Primary reference section

Many individual type sections for the component formations of the group.

Formal subdivisions

Fletcher (1967, 1977) proposed fourteen members which are herein considered as formations, in ascending order; the Cloghfin Sponge Formation, Galboly Chalk Formation, Cloghastucan Chalk Formation, Creggan Chalk Formation, Boheeshane Chalk Formation, Larry Bane Chalk Formation, Ballintoy Chalk Formation, Glenarm Chalk Formation, Garron Chalk Formation, Portrush Chalk Formation, Ballymagarry Chalk Formation, Tanderagee Chalk Formation, Port Calliagh Chalk Formation and Ballycastle Chalk Formation. He informally divided the succession into a Pre-Larry Bane Chalk White Limestone, Larry Bane Formation and Post-Larry Bane Chalk White Limestone parts. The two divisions above and below the Larry Bane Chalk Formation are regarded as subgroups herein but their name is shortened by the omission of the white limestone descriptor.

Lithology

Principally limestones (hardened chalks) with subordinate flint, marl, sponge bed, hardground, conglomeratic and fossil acme bands, with glauconite grains where formations become condensed over structural highs.

Definition of upper boundary

Eroded contact where the group is overlain by the Palaeogene Antrim Basalts or Quaternary deposits.

Definition of lower boundary

Rests disconformably on various members of the Hibernian Greensands Formation and oversteps (unconformable) onto older pre-Cretaceous rocks. Internal overstep within the group principally at the level of the Post-Larry Bane White Limestone Subgroup (informal term defined below) places successively higher formations at the base of the group over structural highs at the margins of the principal basins.

Thickness

Highly variable dependant on the position within structurally controlled basins environments of which five were named by Fletcher (1977) as the Hebridean Basin (presumably incorporating his Londonderry Shelf and North Antrim Basin), the Highland Border (also termed the Dalradian Massif), the Midland Valley (usually termed the East Antrim Basin) and the Southern Uplands. Up to 150 m+ of 'White Limestone' was encountered in the Aughrimderg Borehole [H 880 685] (Wilson, 1972, p.56) but the thickest and most complete development at outcrop is found on the North Antrim coast where 120 m of beds are present, although not at any one locality. The Geological Society Special Report on the Cretaceous (Rawson et al., 1978) gives a value of 130 m.

Distribution

Throughout Northern Ireland. Fullest development in the North Antrim Basin with significant successions in the Midland Valley (East Antrim Basin) and the Southern Uplands as defined in Fletcher (1977).

Previous names

Upper Chalk (White Limestone) and Lower Chalk (Glauconitic Chalk) by Portlock (1843); Upper Chalk divided into an upper White Limestone (or Hard Chalk) and a lower Chloritic Chalk (or Basement bed of the White Limestone) by Tate (1865); Reid (1958) included a 'Basal Conglomerates' within Tate's definition of the Chloritic (correctly termed Glauconitic) Chalk. Ulster White Limestone Formation of BGS publications and Fletcher (1977).

Parent

None

Age and biostratigraphy

Upper Cretaceous, Santonian to Maastrichtian. *Uintacrinus socialis* to *Belemnitella occidentalis occidentalis* (see Wood, 1967) zones.

References

Fletcher, 1967, 1977; Griffith and Wilson, 1982.

The following entries, in stratigraphical order from the base, for the subgroups and formations of the Ulster White Limestone Group form part of the Lexicon derived from its precursor Dic_Strat (as code only entries). They are not shown individually upon maps of Northern Ireland but are described in various publications from the province (see note above concerning the adoption of Ulster White Limestone Group as the formal notation for this succession thus raising the rank of each of the following).

5.2.1 Pre-Larry Bane Chalk Subgroup

Name

Proposed as the Pre-Larry Bane Chalk White Limestone by Fletcher (1977) as an informal term to cover the Santonian and lower Campanian Chalks below the lowest of three distinctive and traceable erosion surfaces marking the Larry Bane Chalk Formation.

Type section

Defined at the type sections of its constituent formations. East Antrim Depositional Basin around Glenarm [D 310 150] and marginally less well developed in the North Antrim Basin in the White Park Bay [D 027 440] area.

Primary reference section

White Park Bay [D 027 440].

Formal subdivisions

Fletcher (1977) proposed five members that are herein considered as formations. They are in ascending order the Cloghfin Sponge Formation, Galboly Chalk Formation, Cloghastucan Chalk Formation, Creggan Chalk Formation, and the Boheeshane Chalk Formation.

Lithology

Chalk with flints and a basal glauconitic arenaceous member.

Definition of upper boundary

Taken at the base of the Larry Bane Chalk Formation where it is marked by the lower of three persistently strong erosion surfaces.

Definition of lower boundary

Rests unconformably on the Hibernian Greensands Formation within the deep depositional basins and on a

variety of older deposits as the subgroup oversteps onto the bounding structural highs.

Thickness

Amounts to 37.19 m from type sites of constituent members and 26 m in the East Antrim Depositional Basin south of Glenarm.

Distribution

Present in the East Antrim and North Antrim basins overstepped by the Ballintoy Chalk Formation and higher units over structural highs.

Previous names

None formally but may be considered as equivalent to those defined as 'Beds earlier than the zone of *Belemnitella mucronata*' by Hancock (1961). This group of sediments are usually easily recognised by the presence above of the characteristic Larry Bane Chalk Formation and is reported (Fletcher, 1977) to be recognisable within downhole geophysical logs.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Santonian to Campanian. *Uintacrinus socialis* to *Gonioteuthis quadrata* and basal *Belemnitella mucronata* zones.

References

Fletcher, 1977; Griffith and Wilson, 1982.

5.2.1.1 Cloghfin Sponge Formation

Name

The Cloghfin Sponge Beds Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded herein as a formation and the name altered to the Cloghfin Sponge Formation.

Type section

As defined in Fletcher (1967) on the shore [J 4760 9110] near Whitehead and Hillsport, Island Magee.

Primary reference section

Restricted to the south-east Antrim region between Little Deer Park near Glenarm and Castle Dobbs. Other principal exposures near Kilcoan [J 461 985] and Cloghfin Port [J 483 938].

Formal subdivisions

None but divided informally into Beds A B and C by Fletcher (1967).

Lithology

Chalk and chalk conglomerate/breccia, glauconitic, with conspicuous hexactinellid sponge psuedomorphs. Three separate beds recognised (A, B, C) each with characteristic shape variants of the irregular echinoid *Echinocorys*.

Definition of upper boundary

The exact relationship with the overlying Galboly Chalk Formation is not certain (Fletcher, 1978 p. 8 para. 2). It is taken at a well-developed separation plane below which the beds contain arenaceous 'contamination'.

Definition of lower boundary

Everywhere the base rests unconformably upon eroded Hibernian Greensand Group successions. In the most complete Hibernian Greensands Formation sequences (Kilcoan [J 461 985]) the base of the Clochfin Sponge Formation is 4.27 m above the conspicuous Inoceramus Bands.

Thickness

As defined in the type site the beds are 1.4 m thick.

Distribution

Limited to the East Antrim Basin Northern Ireland.

Previous names

Cloghfin Sponge Beds Member (note the term Beds is removed from the new name designation to remove ambiguity). Equivalent to the 'Spongiarian Zone' of Hume (1897) and later called the 'Sponge Bed' by Hancock (1961).

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Santonian. *Uintacrinus socialis* Zone in part.

References

Fletcher, 1967, 1977.

5.2.1.2 Galboly Chalk Formation

Name

The Galboly Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Roadside 'pillar' south of Garron Point [Irish Grid Reference D 301 245] but this site is noted in Fletcher (1977) as being within an unstable residual block near to the main road. An alternative type section can be built up from foreshore blocks or from the indifferently exposed old quarry at Milltown [D 255 243].

Primary reference section

Milltown [D 255 243] and in central Murlough Bay [D 200 401].

Formal subdivisions

None

Lithology

Chalk, with some flint bands and 'incipient flints'. Marl partings common to base with some glauconite.

Definition of upper boundary

At a prominent bedding plane (an erosion surface in part) immediately above a zone of wavy and disturbed bedding. Overlain by the Cloghastucan Chalk Formation.

Definition of lower boundary

The exact relationship with the underlying Cloghfin Sponge Formation is not certain (Fletcher, 1978 p. 8 para 2). It is taken at a well-developed separation plane above which the beds contain no appreciable arenaceous 'contamination'.

Thickness

Measures 5.85 m at its type section.

Distribution

Known throughout the North Antrim and East Antrim Basins and part of the Southern Upland, Highland Border and northern Londonderry Shelf. Absent elsewhere.

Previous names

Galboly Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Santonian. *Uintacrinus socialis* Zone (in part).

References

Fletcher, 1967, 1977.

5.2.1.3 Cloghastucan Chalk Formation

Name

The Cloghastucan Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Fallen blocks on the foreshore north of Garron Point [D 301 245], and in Red Bay and Murlough Bay on either side of the Highland Border Ridge.

Primary reference section

Restricted to the North Antrim and East Antrim (Midland Valley) basins, and overlaps, and is itself overlapped (at the Benvan track [D 2000 413]) onto the Highland Border Ridge (Massif). In the North Antrim Basin the formation is continuous from Murlough Bay to the Portrush-Downhill area but diminishes between Oweynamuck and Portbraddan with a concomitant loss of flints. South of the Highland Border Ridge the formation is first seen at Altmore Burn [D 237 228], is absent around Dooray Bridge but attains its maximum thickness on the south side of Red Bay. It overlaps in the south against the Southern Uplands and is absent south of Castle Dobbs.

Formal subdivisions

Contains within it the Oweynamuck Flint Band.

Lithology

Limestone (chalk), with an overall 'gritty' texture and with some flint bands (mainly small and 'spindle-shaped') most notably the coalescing nodular flint course termed the Oweynamuck Flint Band (of bed status defined at the eastern bluff in White Park Bay [D 029 448]). Beds of green-coated chalk pebbles at some levels. Common brachials and calyx plates of *Marsupites*.

Definition of upper boundary

The upper limit is taken at the top of a thin (0.15 m) wavy bedded unit underlying Creggan Chalk Formation chalks rich in *Inoceramus* debris. The wavy bedded unit contains a marked increase in *Inoceramus* compared to the rest of the Cloghastucan Chalk Formation.

Definition of lower boundary

At the type site, the boundary is at a prominent bedding plane immediately above a wavy bedded unit at the top of the underlying Galboly Chalk Formation. Outside the type area the basal contact is disconformable and the junction is marked by an erosion surface with glauconitised chalk pebbles, which includes rolled sponge psuedomorphs.

Thickness

Thin succession of 2.33 m thickness at its type site. Absent over structural highs and overlapped by succeeding members.

Distribution

Present in the North Antrim and East Antrim basins and parts of the Highland Border and Southern Uplands areas. Absent over the Londonderry shelf.

Previous names

Cloghastucan Chalk Member. The *Marsupites* White Limestone (Reid, 1964).

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Santonian. *Marsupites testudinarius* Zone.

References

Fletcher, 1967, 1977.

5.2.1.4 Creggan Chalk Formation

Name

As first published called the Ballykeel Chalk in Fletcher (1967). The Creggan Chalk Member was first proposed in Fletcher (1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Gortin Quarry, Creggan [D 277 187]. The type section of the Ballykeel Chalk in Fletcher (1967) is on the south-east coast of Island Magee at [J 9710 4860].

Primary reference section

Best developed in the North Antrim and Midland Valley Basins particularly in the down-warp areas around Garron and Hillsport. Other localities within these basins to note are at White Park Bay, Boheeshane Bay and Murlough Bay in North Antrim, in Church Bay on Rathlin Island and along the East Antrim coast (Midland Valley Basin). This formation is more widely spread than all older formations overlapping significantly onto the Londonderry Shelf to near Dungiven, onto the Highland Border Ridge as seen at Carneighaneigh Quarry, and onto the Southern Uplands as far south as Collinwell in south Belfast. The stromatolitic surface becomes very prominent in the Southern Uplands area where it was formerly known by the quarrying term 'mulatto'.

Formal subdivisions

None

Lithology

Limestone (chalk), with common *Inoceramus* fragments (up to 20%) and many small burrow-fill flints scattered throughout. The upper part contains several green-coated pebble horizons that coalesce towards the basin margins to form a single conspicuous hardground with rolled and mineralised fossils most notably belemnites and echinoid steinkerns. Glauconitic in marginal overlap facies where

the uppermost beds/surfaces are attenuated, gritty, glauconitic and algal-topped (stromatolitic).

Definition of upper boundary

Taken at the highest of several green-coated chalk pebble beds within the *Inoceramus*-rich limestone. This unit is termed the Bendoo Pebble Bed (of member? status) in the North Antrim Basin. Overlain by the Boheeshane Chalk Formation.

Definition of lower boundary

Taken at the point in the succession where there is a sudden increase in *Inoceramus* fragments. At Creggan this occurs 0.23 m above the Oweynamuck Flint Band within the top of the Cloghastucan Chalk Formation.

Thickness

Measures 3.45 m at the type locality.

Distribution

North Antrim and East Antrim basins and the Southern Upland area. Oversteps onto the Highland Border area and a limited northern part of the Londonderry Shelf.

Previous names

Creggan Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. Lower part of *Offaster pilula* Zone.

References

Fletcher, 1967, 1977.

5.2.1.5 Boheeshane Chalk Formation

Name

The Boheeshane Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Boheeshane Bay [D045 450] in North Antrim Basin.

Primary reference section

Best developed in the North Antrim and East Antrim (Midland Valley) basins. It is overlapped by younger chalk members towards the structural highs. The Whitehead Flint Band is displayed at the reference section at the old quarry (a landfill site) at Whitehead [J474 913].

Formal subdivisions

Includes the Whitehead Flint Band and is informally divided into units A, B and C.

Lithology

Limestone (chalk), with common massive flint bands and tabular flints. Some green-coated chalk pebble beds near the base and as a prominent bed associated with sponges in the middle of the sequence. Hard pellet chalk in softer matrix is common at some levels. Divided into three main 'beds' (A, B and C) each further divided into numbered 'units'. Each 'bed' separated by marked bedding planes that are locally emphasised by weathering. A number of notable fossil acmes throughout. Considered to be much finer-grained than older gritty members and termed 'White Chalk' by Wolfe (1968). A distinctive massive flint band, which marks the upper limit of *Gonioteuthis*, is termed the Whitehead Flint Band (of bed status) whose type reference section is the old quarry at Whitehead [J 474 913].

Definition of upper boundary

Taken at the well-developed erosional surface at the base of the Larry Bane Chalk Formation.

Definition of lower boundary

Base defined by reference to the terminal pebble bed of the Creggan Chalk Formation and the stromatolitic 'mulatto' surface in marginal areas.

Thickness

Combined thickness at the type site of 24.19 m. Bed A 8.33 m, Bed B 8.69 m and Bed C 7.17 m.

Distribution

North Antrim and East Antrim basins part of the Southern Uplands area and over parts of the Highland Border and Londonderry Shelf areas.

Previous names

Boheeshane Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Gonioteuthis quadrata* and basal *Belemnitella mucronata* zones. From *Applinocrinus* [*Saccocoma*] *cretaceus* Subzone (*quadrata* Zone).

References

Fletcher, 1967, 1977.

5.2.2 Larry Bane Chalk Formation

Name

The Larry Bane Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Larry Bane Bay [D058 452]. Specifically in the cliff section [D 0500 4500] 400 metres north-north-east of Ballintoy in the North Antrim Basin.

Primary reference section

North Antrim Basin particularly Carrickarade to Portbraddan and in the East Antrim Basin.

Formal subdivisions

Informally divided into units A and B, which are said to have a characteristic one-third (A) to two-thirds (B) thickness relationship throughout the province.

Lithology

Limestone (chalk) with numerous flint bands. Shell debris abundant with distinct 'pellet' or fragmentary limestone clasts evident on weathered surfaces. Three persistent erosion surfaces divide the Larry Bane Chalk Formation

into two 'Beds' (A and B). These surfaces may be treated as marl seams. Very large belemnites are a prominent feature of this formation.

Definition of upper boundary

Conformable at an upper prominent erosion surface/marl beneath the Ballintoy Chalk Formation. Overlapped by younger members at margins of structural highs.

Definition of lower boundary

Conformable at lower prominent erosion surface/marl resting on Boheeshane Chalk Formation.

Thickness

Totals 7.29 m at type site with Bed A 2.44 m and Bed B 4.85 m thick. This 1:2 ratio of bed thickness is considered to be characteristic of the whole Larry Bane Chalk Formation outcrop.

Distribution

Known throughout the North Antrim and East Antrim (Midland Valley) basins of Northern Ireland.

Previous names

Larrybane Chalk of Fletcher (1967); Larry Bane Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* Zone.

References

Fletcher, 1967, 1977.

5.2.3 Post-Larry Bane Chalk Subgroup

Name

Proposed by Fletcher (1977) as the Post-Larry Bane Chalk White Limestone as an informal term to cover the upper Campanian and Maastrichtian Chalks above the highest of three distinctive and traceable erosion surfaces marking the top of the Larry Bane Chalk Formation.

Type section

Ballycastle area [D 115 420], North Antrim Basin.

Primary reference section

Cliff and quarry sections around Ballycastle [D 114 420]; Whiterocks [C 893 409] and Garron Point [D 301 239].

Formal subdivisions

Fletcher (1977) proposed eight members that are regarded as formations herein. They are in ascending order the Ballintoy Chalk Formation, Glenarm Chalk Formation, Garron Chalk Formation, Portrush Chalk Formation, Ballymagarry Chalk Formation, Tanderagee Chalk Formation, Port Calliagh Chalk Formation and the Ballycastle Chalk Formation

Lithology

Limestone (chalk) with layers of nodular, tabular and 'paramoudra' type flints.

Definition of upper boundary

Placed at the erosion surface at the top of Ulster White Limestone Group succession beneath Palaeogene Antrim basalt.

Definition of lower boundary

Placed at base of Ballintoy Chalk Formation at the top of the Larry Bane Chalk Formation where it is marked by the upper of three persistently strong erosion surfaces.

Thickness

A total of 89.28 m from type sites of constituent members, but the full thickness is very variable due to pre-Palaeogene Basalts erosion.

Distribution

Known throughout Northern Ireland. Its major development is in the North Antrim, East Antrim and Southern Upland basins. Oversteps onto structural highs.

Previous names

None formally but may be considered as the partial equivalent to those defined as 'Beds of the zone of *Belemnitella mucronata*' by Hancock (1961). This group of sediments are usually easily recognised by the presence, in sections, of the characteristic underlying Larry Bane Chalk Formation and is reported by Fletcher (1977) to be recognisable within downhole geophysical logs.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Upper Campanian to Maastrichtian. *Belemnitella mucronata* to *Belemnella occidentalis* zones.

References

Fletcher, 1967, 1977; Griffith and Wilson, 1982.

5.2.3.1 Ballintoy Chalk Formation

Name

The Ballintoy Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

The type section is taken on gently dipping rock platforms in Ballintoy Harbour [D 040 456] in the North Antrim Basin. More accurate measurements are achieved from Larry Bane Head and Quarry to the east. The maximum development of the member was formerly visible in air-weathered cliffs in White Bay. The type section was defined by Fletcher in his 1967 thesis is at White Bay [D 3280 1510].

Primary reference section

North Antrim and Midland (East Antrim) basins and on the eastern Londonderry Shelf. The member is continuous around the outcrop from Portrush to north Belfast.

Formal subdivisions

The highest unit within the formation is named the Altachuile Breccia (member). The whole formation is divided informally from the base into A and B units.

Lithology

Limestone (chalk) with small flints scattered in the lower part and small discontinuous tabular flints in the upper part. The formation can be divided two 'beds' (A and B) separated by conspicuous separation planes. The formation is terminated by the 'wavy-bedded' Altachuile Breccia (member).

Definition of upper boundary

Conformably succeeded by the Glenarm Chalk Formation above the Altachuile Breccia (member).

Definition of lower boundary

Conformably overlies 'Bed' B of the Larry Bane Chalk Formation. Oldest of the post-Larry Bane Chalk 'Subgroup'.

Thickness

Totals 12.65 m at its type site with Bed A 9.65 m and Bed B 3.00 m.

Distribution

Principal outcrop is within the North Antrim and East Antrim (Midland Valley) basins. Oversteps the Larry Bane Formation onto the Southern Uplands, Highland Border and the northernmost part of the Londonderry Shelf.

Previous names

White Bay Chalk of Fletcher (1967); Ballintoy Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* Zone sensu lato.

References

Fletcher, 1967, 1977.

5.2.3.2 Glenarm Chalk Formation

Name

The Glenarm Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Old quarry at Parishagh [D 304 156], half a mile north-west of Glenarm in the Midland Valley (East Antrim) Basin.

Primary reference section

Cliff sections at White Rocks near Portrush and in the quarry at Larry Bane Head in the northern depositional basin. The sections around Glenarm in the Midland Valley Basin.
At Kilwaughter [D354 008] and Ballycarry [J449 943].

Formal subdivisions

Includes the North Antrim Hardgrounds (of member status) and is informally divided into units A to D from the base.

Lithology

Limestone (chalk), with flints ranging from small nodular at the base through nodular to tabular flints in the middle part of the succession to massive nodular at the top. The formation can be divided into four 'Beds' (A to D) by subdivision on bedding planes. In the North Antrim Basin the formation includes two well-developed hardgrounds, the North Antrim Hardgrounds (of member? status) and the succession is therefore incomplete. In the Midland Valley (East Antrim) Basin only limited wavy bedding and scattered green glauconitised pebbles indicate interrupted sedimentation. This area is regarded as the 'standard'.

Definition of upper boundary

Weathered-out bedding plane below conspicuously shelly wavy-bedded chalk at the base of the conformable Garron Chalk Formation.

Definition of lower boundary

Base delimited by a prominent weathered-out bedding plane immediately above the Altachuile Breccia (member) of the Ballintoy Chalk Formation.

Thickness

Some 8.10 m at the type area.

Distribution

Maximum development in the East Antrim (Midland Valley) Basin and found over the Highland Border High and well developed in the North Antrim Basin. Becomes attenuated including several non-sequences and overstepped by younger formations across the Londonderry Shelf and in the Southern Uplands Belfast district.

Previous names

Glenarm Chalk of Fletcher (1967); Glenarm Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* Zone sensu lato.

References

Fletcher, 1967, 1977.

5.2.3.3 Garron Chalk Formation

Name

The Garron Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Cliff section just north of the Post Office at Garron Point [D 301 239].

Primary reference section

Whiterocks and Larry Bane Head in the North Antrim Basin. Portaneevy [D 063 444] on the north coast, Portantonnish on Rathlin Island and Ballysillan Quarry [J 305 778] show the characteristic giant 'flint-circles'.

Formal subdivisions

None but divided informally into Units A to C from the base.

Lithology

Limestone (chalk) with characteristic giant flints ('massive flint rolls') and significant *Inoceramus* fragments. Is divided into three 'Beds' (A to C).

Definition of upper boundary

Conformable with Portrush Chalk Formation at a bedding plane above wavy-bedded sediment with small nodular flints.

Definition of lower boundary

Conformable on the Glenarm Chalk Formation at a bedding plane, above which wavy-bedded conspicuously shelly chalk with corals and bryozoa occurs.

Thickness

Some 9.65 m in type section.

Distribution

North Antrim Basin, East Antrim (Midland Valley) Basin and over structural highs with the exception of the southern and western Londonderry Shelf. Oversteps younger beds over structural highs.

Previous names

Garron Chalk of Fletcher, 1967; Garron Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* Zone sensu lato.

References

Fletcher, 1967, 1977.

5.2.3.4 Portrush Chalk Formation

Name

The Portrush Chalk Member was first proposed in Fletcher (1967, 1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Taken at the south-facing wall of the older and deeper Ballymagarry Quarry [C 890 408], i.e. immediately above the main cave which passes beneath the Portrush to Bushmills Road. Sliddery Cove Cliffs [C 890 410] east of Portrush.

Primary reference section

Garron Point [D 301 2390] in East Antrim Basin.

Formal subdivision

Includes the South Antrim Hardgrounds (of member status) and informally divided into units A to D from the base.

Lithology

Limestone (chalk) with many tabular flint bands and *Inoceramus* debris in upper part. In the south Antrim area (Southern Uplands High) there are important hardground non-sequences of green-coated chalk pebbles called the South Antrim Hardgrounds (of member status).

Definition of upper boundary

At a prominent bedding plane above *Inoceramus*-rich chalk with tabular flint.

Definition of lower boundary

Conformable, on the Garron Chalk Formation, at a bedding plane beneath a prominent continuous tabular flint.

Thickness

About 14.28 m in the type section.

Distribution

Found consistently throughout the province but is generally absent from much of the East Antrim (Midland Valley) Basin due to pre-Palaeogene basalt erosion. Oversteps onto older strata over the Londonderry Shelf.

Previous names

Portrush Chalk of Fletcher (1967); Portrush Chalk Member. Is equivalent to the Cardiaster Beds described by Wood (in Wilson, 1972). The term 'Green Beds' is utilised as a mappable unit in Manning et al., (1970) for the South Antrim Hardgrounds.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* Zone sensu lato.

References

Fletcher, 1967, 1977.

5.2.3.5 Ballymagarry Chalk Formation

Name

The Ballymagarry Chalk Member was first proposed in Fletcher (1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Ballymagarry Quarry [C 889 407].

Primary reference section

The western side of Port More [D 073 439] and Downhill in north Derry. Found throughout the Londonderry Shelf, North Antrim Basin and Southern Uplands High. Absent from the Midland Valley (East Antrim) Basin and Highland Border High.

Formal subdivisions

None but informally divided into units A to C from the base.

Lithology

Limestone (chalk) with extremely large flat lying and near-continuous flint bands. Divided into three 'Beds' (A to C) separated by well-marked bedding planes.

Definition of upper boundary

Marked by the base of the prominent continuous flint band termed the Long Gilbert Flint Band within the Tanderagee Chalk Formation.

Definition of lower boundary

Conformably overlies the Portrush Chalk Formation at a level of a well-marked bedding plane immediately below the inception of large flat lying and near continuous flint nodules.

Thickness

About 10.95 m at its type site.

Distribution

Absent from the Highland Border High and East Antrim Basin presumably by pre-Palaeogene erosion.

Previous names

Ballymagarry Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Belemnitella mucronata* Zone sensu lato.

References

Fletcher, 1977.

5.2.3.6 Tanderagee Chalk Formation

Name

The Tanderagee Chalk Member was first proposed in Fletcher (1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Long Gilbert Quarry, Ballymagarry [C 889 407], south wall of the western part of the quarry.

Primary reference section

Numerous in the North Antrim Basin, the southern Londonderry Shelf and in the Southern Uplands. It is seen in sections between Magheralin and Trummery, Groganstown and the 'Hairpin Bend' region of Ballysillan, Ballycastle to Ballintoy, Portbraddan to Downhill and between Carmean and Stewartstown.

Formal subdivision

Includes the Long Gilbert Flint Band (of bed status) and informally divided into units A to E from the base.

Lithology

Limestone (chalk) with flint bands. Divided into five 'Beds' (A to E). Abundant belemnites in lower 'Bed' A and by an acme of crinoid debris in 'Bed' C. Elsewhere asteroid and crinoid debris common.

Definition of upper boundary

Conformable, with the overlying Port Calliagh Chalk Formation, at a bedding plane below a 'belt of complex flints'.

Definition of lower boundary

Conformable, on the Ballymagarry Chalk Formation, at a bedding plane immediately below the thick continuous tabular Long Gilbert Flint Band where this exists. Or at the same bedding plane marking the faunal change from the Ballymagarry Chalk Formation fauna.

Thickness

About 7.63 m at type site.

Distribution

Outcrops in the Southern Uplands area, the North Antrim Basin and in the southern part of the Londonderry Shelf. Absent in the East Antrim Basin, the Highland Border High and northern Londonderry shelf due to pre-Palaeogene erosion.

Previous names

Tanderagee Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Maastrichtian. *Belemnella lanceolata* Zone?

References

Fletcher, 1977.

5.2.3.7 Port Calliagh Chalk Formation

Name

The Port Calliagh Chalk Member was first proposed in Fletcher (1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

Port Calliagh [D 112 420] inlet west of Castle Point near Ballycastle, north Antrim and to the east under Castle Point.

Primary reference section

Ballymagarry Quarry and around Ballycastle Harbour in the North Antrim Basin, in three quarries on the western Londonderry Shelf region, at Whiterock in Belfast and in Small and Hayes Quarry north-east of Lurgan.

Formal subdivision

None but informally divided into units A to F from the base.

Lithology

Limestone (chalk) with numerous flint bands displaying large, tabular and complex habit.

Definition of upper boundary

Conformable at a prominent weathered-out bedding plane at the top of 'Bed' F with the Ballycastle Chalk Formation.

Definition of lower boundary

Conformable on the Tanderagee Chalk Formation at the lowest 'separation plane' immediately beneath the 'belt of complex flints' seen in the Ballycastle section.

Thickness

Some 12.40 m at the type site.

Distribution

Outcrops in the Southern Uplands area (in isolated areas), the North Antrim Basin and in the southern part of the Londonderry Shelf. Absent in the East Antrim Basin, the Highland Border High and northern Londonderry Shelf due to pre-Palaeogene erosion.

Previous names

Port Calliagh Chalk Member. Forms the lower part of the Ballycastle White Limestone (Wood, 1967).

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Maastrichtian. *Belemnella lanceolata* Zone.

References

Fletcher, 1967, 1977.

5.2.3.8 Ballycastle Chalk Formation

Name

The Ballycastle Chalk Member was first proposed in Fletcher (1977) and adopted in BGS publications subsequently. It is regarded as a formation herein.

Type section

West of Ballycastle Pier [D 120 415].

Primary reference section

Ballymagarry Quarry, Castle Point Quarry and cliffs and foreshore eastward to Ballycastle.

Formal subdivision

None but informally divided into units A to G from the base.

Lithology

Limestone (chalk) with nodular flint bands which have a carious habit in the upper part of the formation. Divided into seven 'beds' (A to G).

Definition of upper boundary

Erosional contact with Palaeogene basalts or Quaternary deposits.

Definition of lower boundary

Conformable on the Port Calliagh Chalk Formation at a prominent weathered-out bedding plane at the top of 'Bed' F of that lower formation and characterised by tabulate flints.

Thickness

Some 13.72 m at type site.

Distribution

Limited to the Ballymagarry and Ballycastle areas by pre-Palaeogene erosion.

Previous names

Forms the upper part of the Ballycastle White Limestone of Wood (1967). Ballycastle Chalk Member.

Parent

Ulster White Limestone Group.

Age and biostratigraphy

Upper Cretaceous, Maastrichtian. *Belemnella occidentalis* Zone.

References

Fletcher, 1967, 1977.

6 Note on the Chalk Group nomenclature in the UK Offshore sector

Investigations into the hydrocarbon prospectivity of the North Sea has led to the development from an early, essentially downhole geophysical log and seismic, stratigraphy into a more refined lithostratigraphical nomenclature based not only on geophysical data but on biostratigraphy, cuttings and type cores. In the UK sector the first comprehensive lithostratigraphical schemes were established by Rhys (1974) (Figure 11, Column 1) in the Southern North Sea and by Deegan and Scull (1977) (Figure 11, Column 2) in the Central and Northern North Sea (east of the Shetland Islands and southwards). The terms, developed in those early studies, have been expanded with a considerable body of stratigraphical evidence and piecemeal additions were made such that the meaning of many lithostratigraphical terms became blurred. The 'BGS under the auspices of the UKOOA (UK Offshore Operators Association)' published a rationalisation of this nomenclature in seven volumes (under the editorship of Knox and Cordey) with Volume 2 (Johnson and Lott, 1993) (Figure 11, Column 3), and Volume 7 (Lott and Knox, 1994) (Figure 11, Column 4) covering the Cretaceous strata of the Central and Northern North Sea, and the Southern North Sea respectively.

Three similar volumes were produced by BGS to cover the UK sector North-west Margin with Volume 1 giving a correlation of the pre-Tertiary lithostratigraphy (Ritchie, Gatliff and Riding, 1996) (Figure 11, Column 5). This covered the area west of the Shetland Islands southward to the Orkneys Islands.

The most recent review of the stratigraphy of the offshore sector is contained in *The Millennium Atlas: petroleum geology of the central and northern North Sea* published by the Geological Society of London in 2002 (Surlyk et al., 2003). This contains a comprehensive overview of the stratigraphy within the Danish, Norwegian and UK sectors of the hydrocarbon-producing regions of the North Sea, north of latitude 55° 20´ N, and updates the UKOOA and BGS volumes.

Data is also held within the Offshore Regional Reports of the BGS published between 1990 and 1996 although in general the terminology used reflects their compilation prior to the UKOOA volumes.

A detailed discussion is beyond the scope of this report but a correlation of the lithostratigraphical units given in the UKOOA publications is given in Figure 11 for completeness. Two aspects of the offshore terminology should be noted.

The Hunstanton Formation is considered to be of Albian age and equivalent to the Rødby Formation in the Cromer Knoll Group.

In general the Hidra Formation and its lateral equivalents correlate roughly to the Grey Chalk Subgroup or Ferriby Chalk Formation with the Plenus Marl Formation and/or the Black Band at the base of the Herring Formation (and lateral equivalents) marking the base of the White Chalk Subgroup. However it should be noted that the use of the terms Plenus Marl Formation and Black Band within the offshore sector is confused and they are not necessarily mutually exclusive. Indeed in correlation charts the Black Band is shown spanning the Cenomanian/Turonian boundary and must therefore include the entirely Cenomanian Plenus Marls Member as defined onshore. It follows therefore that where the Black Band defines the base of the Herring Formation this may or may not include the Plenus Marls succession and similarly the Plenus Marl Formation may encompass the Black Band. It is quite possible therefore that the topmost part of the Hidra Formation should be considered as equivalent to the very basal White Chalk Subgroup.

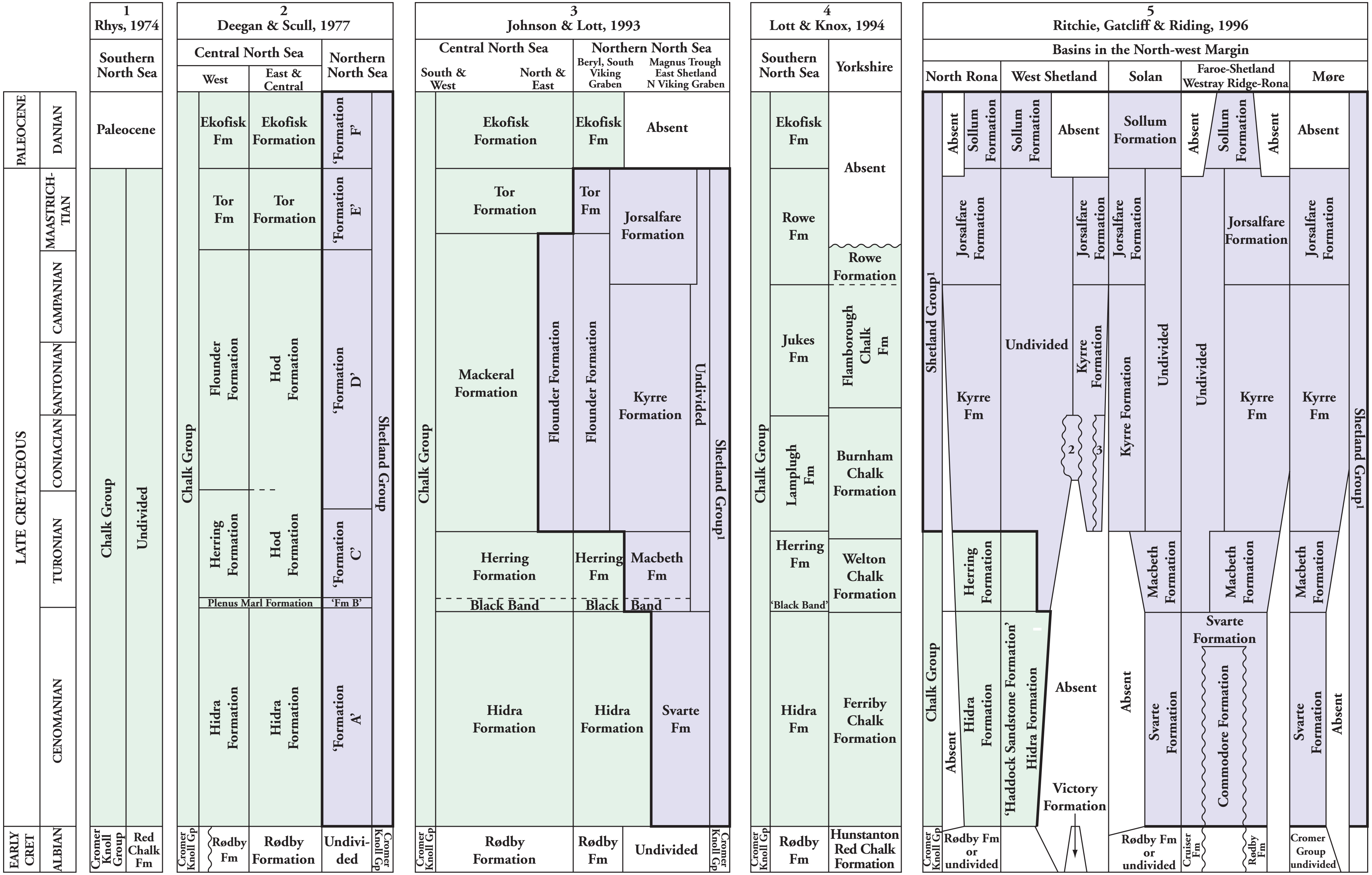


Figure 11 The development of the terminology in the offshore UK Sector.

References

ALDISS, D T. 1990. Geological notes and local details for 1:10 000 Sheet SP92SE (Totternhoe), and part of Sheet SP91NE. *British Geological Survey Technical Report*, WA/91/51.

ALDISS, D T. 2002. Geology of the Chichester and Bognor district. *British Geological Survey Sheet Description*. Sheet 317 and part of 332 (England and Wales).

ANDREWS, J. 1983. A faunal correlation of the Hunstanton Red Rock with the contemporaneous Gault Clay, and its implications for the environment of deposition. *Bulletin of the Geological Society of Norfolk*, Vol. 33, 3–26.

ARTHURTON, R S, BOOTH, S J, MORIGI, A N, ABBOTT, M A W, and WOOD C J. 1994. Geology of the country around Great Yarmouth. *Memoir of the British Geological Survey*, Sheet 162 (England and Wales).

BAILEY, E B. 1924. The desert shores of the Chalk sea. *Geological Magazine*, Vol. 61, 102–116.

BAILEY, E B, and ANDERSON, F M. 1925. Geology of Staffa, Iona and Western Mull. *Memoir of the Geological Survey of Great Britain*, Sheet 43 (Scotland).

BARKER, R D, LLOYD, J W, and PEACH, D W. 1984. The use of resistivity and gamma logging in lithostratigraphical studies of the Chalk in Lincolnshire and South Humberside. *Quarterly Journal of Engineering Geology*, Vol. 17, 71–80.

BARROIS, C. 1876. Recherches sur le terrain Crétacé superieur de l'Angleterre et de Irlande. *Mémoires de la Société Géologique du Nord*, 234pp.

BARTON, C M. 1991. Geology of the Blandford Forum district. *British Geological Survey Technical Report*, WA/91/81.

BERRIDGE, N G, and PATTISON, J. 1994. Geology of the country around Grimsby and Patrington. *Memoir of the British Geological Survey*, Sheets 81, 82, 90 and 91 (England and Wales).

BLAKE, J F. 1878. On the Chalk of Yorkshire. *Proceedings of the Geologists' Association*, Vol. 5, 232–270.

BOGG, E. 1816. A sketch of the Geology of the Lincolnshire Wolds. *Transactions of the Geological Society of London*, Vol. 3, p. 392.

BOWER, C R, and FARMLEY, J R. 1910. The zones of the Lower Chalk of Lincolnshire. *Proceedings of the Geologists' Association*, Vol. 21, 333–359.

BRALEY, S M. 1990. The Sedimentology, Palaeoecology and Stratigraphy of Cretaceous Rocks in N.W. Scotland. Unpublished PhD Thesis CNAA, Polytechnic SouthWest (now University), Plymouth.

BRIGHTON, A G. 1928. Notes on the Middle and Upper Chalk of the Cambridge District. *Geological Magazine*, Vol. 65, 368–371.

BRISTOW, C R. 1989. Geology of the East Stour – Shaftesbury district (Dorset). *British Geological Survey Technical Report*, WA/89/58.

BRISTOW, C R. 1990a. Geology of the Berwick St John district, Wiltshire. *British Geological Survey Technical Report*, WA/90/49.

BRISTOW, C R. 1990b. Geology of the country around Bury St Edmunds. *Memoir of the British Geological Survey*, Sheet 189 (England and Wales).

BRISTOW, C R, MORTIMORE, R N, and WOOD, C J. 1997. Lithostratigraphy for mapping the Chalk of southern England. *Proceedings of the Geologists' Association.* Vol. 108, 293–315.

BRISTOW, C R, MORTIMORE, R N, and WOOD, C J. 1999. 'Lithostratigraphy for mapping the chalk in southern England' by Bristow et al. (1997): discussion. *Proceedings of the Geologists' Association*, Vol. 110, 68–72.

BRISTOW, C R, BARTON, C M, FRESHNEY, E C, WOOD, C J, EVANS, D J, COX, B M, IVIMEY-COOK, H, and TAYLOR, R. 1995. Geology of the country around Shaftesbury. *Memoir of the British Geological Survey*, Sheet 313 (England and Wales).

BRISTOW, C R, BARTON, C M, WESTHEAD, R K, FRESHNEY, E C, COX, B M, and WOODS, M A. 1999. The Wincanton district — a concise account of the geology. *Memoir of the British Geological Survey*, Sheet 297 (England and Wales).

BROMLEY, R G, and GALE, A S. 1982. The Lithostratigraphy of the English Chalk Rock. *Cretaceous Research,* Vol. 3, 273–306.

BRYCE, J. 1853. On the geological structure of the Counties of Down and Antrim. *Report of the British Association* [for 1852], Vol. 22, 42–43.

BRYDONE, R M. 1908. On the subdivisions of the Chalk of Trimmingham (Norfolk). *Quarterly Journal of the Geological Society of London*, Vol. 54, 401–412.

CHRISTENSSEN, W K. 1995. *Belemnitella* from the Upper Campanian and Lower Maastrichtian Chalk of Norfolk, England. *Special Papers in Palaeontology*, Vol. 51, 84pp.

CHRISTENSSEN, W K. 1999. Upper Campanian and Lower Maastrichtian belemnites from the Mons Basin, Belgium. *Bulletin de l'Institut Royal des Sciences Naturalles de Belgique*, *Sciences de la Terra*, Vol. 69, 97–131.

COX, F C, GALLOIS, R W, and WOOD, C J. 1989. Geology of the country around Norwich. *Memoir of the British Geological Survey*, Sheet 161 (England and Wales).

DAKYNS, J R, and FOX-STRANGWAYS, C. 1886. The geology of the country around Driffield. *Memoir of the Geological Survey of the United Kingdom*.

DAKYNS, J R, and FOX-STRANGWAYS, C, and CAMERON, A G. 1886. The geology of the country between York and Hull. *Memoir of the Geological Survey of the United Kingdom*.

DEEGAN, C E, and SCULL, B J. 1977. A standard lithostratigraphic nomenclature for the Central and Northern North Sea. *Report of the Institute of Geological Sciences*, No. 77/25.

DODSWORTH, P. 1996. Stratigraphy, microfossils and depositional environments of the lowermost part of the Welton Chalk Formation (late Cenomanian to early Turonian, Cretaceous) in eastern England. *Proceedings of the Yorkshire Geological Society*, Vol. 51, 45–64.

DOWKER, G. 1870. On the Chalk of Thanet, and its connection with the Chalk of East Kent. *Geological Magazine* Vol. 7, 466–72.

DRUMMOND, P V O. 1970. The Mid-Dorset Swell. Evidence of Albian-Cenomanian movements in Wessex. *Proceedings of the Geologists' Association*, Vol. 81, 679–714.

EDMUNDS, E A, and DINHAM, C H. 1965. Geology of the country around Huntingdon and Biggleswade. *Memoir of the Geological Survey of Great Britain*, Sheets 187 and 204 (England and Wales).

EMELEUS, C H. 1997. Geology of Rum and adjacent islands. *Memoir of the British Geological Survey*, Sheet 60 (Scotland).

EVANS, C. 1870. *On some sections of the Chalk between Croydon and Oxtead, with observations on the classification of the Chalk, being a paper read before the Geologists' Association Jan 7th* 1870. (Lewes: G P Bacon.)

FARRANT, A R. 1999. Geology of the Kings Somborne–Winchester district, Hampshire. *British Geological Survey Technical Report*, WA/99/06.

FARRANT, A R. 2000. Geology of the Dean and Wallops area, Hampshire and Wiltshire. *British Geological Survey Technical Report*, WA/00/11.

FITTON, W H. 1836. Observations on some of the strata between the Chalk and the Oxford Oolite, in the south-east of England. *Transactions of the Geological Society of London, second series*, Vol. 4, 103–388.

FLETCHER, T P. 1967. Correlation of the Cretaceous exposures of east Antrim. Unpublished MSc Thesis, Queens University, Belfast.

FLETCHER, T P. 1977. Lithostratigraphy of the Chalk (Ulster White Limestone Formation) in Northern Ireland. *Report of the Institute of Geological Sciences*, No. 77/24.

FORBES, E, and IBBESTON, L L B. 1844. On the Tertiary and Cretaceous Formations of the Isle of Wight. *Report of the British Association, Transactions of Sections for* 1944, p. 43.

FOWLER, A, and ROBBIE, J A. 1961. Geology of the Country around Dungannon. *Memoir of the Geological Survey of Northern Ireland*, Sheet 35 (Northern Ireland).

GALE, A S. 1989. Field meeting at Folkestone Warren, 29th November 1987. P*roceedings of the Geologists' Association*, Vol. 100, 73–80.

GALE, A S. 1995. Cyclostratigraphy and correlation of the Cenomanian of western Europe. 177–197 *in* Orbital forcing timescales and cyclostratigraphy. HOUSE, M R, and GALE, A S (editors). *Geological Society of London Special Publications*, No. 85.

GALE, A S. 1996. Correlation and sequence stratigraphy of the Turonian Chalk of southern England. 177–195 *in* Sequence stratigraphy in British geology. HESSELBO, S P, and PARKINSON, D N (editors). *Geological Society of London Special Publication* No. 103.

GALE, A S. 1999. *Chalk lithostratigraphy; a summary of classification schemes, and suggested points of discussion*. Personal communication to participants at the Chalk Lithostratigraphy meeting held under the auspices of the Geological Society Stratigraphic Framework Committee at the British Geological Survey, November, 1999.

GALE, A S, and CLEEVLEY, R. 1989. Arthur Rowe and the zones of the White Chalk of the English Coast. *Proceedings of the Geologists' Association*, Vol. 100, 419–431.

GALE, A S, and HANCOCK, J M. 1999. 'Lithostratigraphy for mapping the Chalk of southern England' by Bristow et al. (1997): discussion. *Proceedings of the Geologists' Association*, Vol. 110, 65–68.

GALE, A S, WOOD, C J, and BROMLEY, R G. 1987. Lithostratigraphy and marker bed correlation in the White Chalk (Cenomanian–Campanian) of southern England *Mesozoic Research*, Vol. 1, 107–118.

GALLOIS, R W. 1994. Geology of the country around King's Lynn and The Wash. *Memoir of the British Geological Survey*, Sheet 145 and part of 129 (England and Wales).

GASTER, C T. 1944. The stratigraphy of the Chalk of Sussex. Part III. Western area. Arun Gap to the Hampshire boundary, with zonal map. *Proceedings of the Geologists' Association*, Vol.55, p.173–188.

GAULT, W. 1878. Observations on the geology of Black Mountain. *Proceedings of the Belfast Naturalists Field Club*, Series 2, Vol. 1, 251–262.

GAULT, G D, FLETCHER, T P, and WOOD, C J. 1992. Geology of the country around Kingston upon Hull and Brigg. *Memoir of the British Geological Survey*, Sheets 80 and 89 (England and Wales).

GRIFFITH, A E, and WILSON, H E. 1982. Geology of the country around Carrickfergus and Bangor. *Memoir of the Geological Survey of Northern Ireland*. Sheet 29 (Northern Ireland).

HANCOCK, J M. 1961. The Cretaceous System in Northern Ireland. *Quarterly Journal of the Geological Society of London*, Vol. 117, 11–36.

HANCOCK, J M. 1972. (Editor) Crétacé. Ecosse, Angleterre, Pays de Galles. *Lexique Stratigraphique International*, Vol. 1, fascicule 3a XI.

HANCOCK, J M. 2000. The Gribun Formation: clues to the latest Cretaceous history of western Scotland. *Scottish Journal of Geology*, Vol. 36, 137–141.

HART, M B. 1973. Foraminiferal evidence for the age of the Cambridge Greensand. *Proceedings of the Geologists' Association*, Vol. 84, 65–82.

HART, M B, and BIGG, P J. 1981. Anoxic events in the late Cretaceous Chalk seas of Northwest Europe. 177–185 in *Microfossils from Recent and Fossil Shelf Seas.* NEALE, J W and BRASIER, M D, (editors) (Chichester: Ellis Horwood.)

HART, M B, DODSWORTH, P, and DUANE, A M. 1993. The Late Cenomanian Event in eastern England. *Cretaceous Research*, Vol. 14, 495–508.

HAWKES, L. 1943. The erratics of the Cambridge Greensand – their nature, provenance and mode of transport. *Quarterly Journal of the Geological Society of London*, Vol. 99, 93–104.

HEWITT, H D. 1935. Further notes on the Chalk of the Thetford District, Norfolk. *Proceedings of the Geologists' Association*, Vol. 46, 18–37.

HILL, W. 1886. On the beds between the Upper and Lower Chalk of Dover and their comparison with the Middle Chalk of Cambridgeshire. *Quarterly Journal of the Geological Society of London*, Vol. 42, 232–248.

HILL, W. 1888. On the lower beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire. *Quarterly Journal of the Geological Society of London*, Vol. 44, 320–367.

HILL, W, and JUKES-BROWNE, A J. 1886. The Melbourn Rock and the Zone of *Belemnitella plena* from Cambridge to the Chiltern Hills. *Quarterly Journal of the Geological Society of London*, Vol. 42, 216–231.

HOPSON, P M. 1992. Geology of the Letchworth, north-west Hitchin and Holwell district, Hertfordshire. *British Geological Survey Technical Report*, WA/92/42.

HOPSON, P M. 1999. The Chalk Aquifer Study: A review of the current state of knowledge of the Chalk in the North Downs. *British Geological Survey Technical Report*, WA/99/24.

HOPSON, P M, ALDISS, D T, and SMITH, A. 1996. The geology of the country around Hitchin. *Memoir of the British Geological Survey*, Sheet 221 (England and Wales).

HUDSON, J D. 1960. The Laig Gorge Beds, Isle of Eigg. *Geological Magazine*, Vol. 97, 313–325.

HUME, W F. 1897. The Cretaceous strata of County Antrim. *Quarterly Journal of the Geological Society of London*, Vol. 53, 540–606.

HUMPHRIES, D W. 1961. The Upper Cretaceous White Sandstone of Loch Aline, Argyll, Scotland. *Proceedings of the Yorkshire Geological Society*, Vol. 33, 47–63.

JARVIS, I, and TOCHER, B A. 1987. Field meeting: the Cretaceous of SE Devon, 14–16th March, 1986. *Proceedings of the Geologists' Association*, Vol. 98, 51–66.

JARVIS, I, and WOODROOF, P B. 1984. Stratigraphy of the Cenomanian and basal Turonian (Upper Cretaceous) between Branscombe and Seaton, SE Devon, England. *Proceedings of the Geologists' Association*, Vol. 95, 193–215.

JEANS, C V. 1973. The Market Weighton Structure: tectonics, sedimentation and diagenesis during the Cretaceous. *Proceedings of the Yorkshire Geological Society*, Vol. 39, 409–444.

JEANS, C V. 1980. Early submarine lithification in the Red Chalk and Lower Chalk of Eastern England: a bacterial control model and its implications. *Proceedings of the Yorkshire Geological Society*, Vol. 43, 81–157.

JEANS, C V, LONG, D, HALL, M A, BLAND, D J, and CORNFORD, C. 1991. The geochemistry of the Plenus Marls at Dover, England: evidence of fluctuating oceanographic conditions and of glacial control during the development of the Cenomanian–Turonian $d^{13}C$ anomaly. *Geological Magazine*, Vol. 128, 603–632.

JEFFERIES, R P S. 1963. The stratigraphy of the *Actinocamax plenus* Subzone (Turonian) in the Anglo-Paris Basin. *Proceedings of the Geologists' Association*, Vol. 74, 1–33.

JOHANSEN, M B, and SURLYK, F. 1990. Brachiopods and the stratigraphy of the Upper Campanian and Lower Maastrichtian Chalk of Norfolk, England. *Palaeontology*, Vol. 33, 823–873.

JOHNSON, H, and LOTT, G K. 1993. Cretaceous of the Central and Northern North Sea. Volume 2 in *Lithostratigraphic nomenclature of the UK North Sea*. KNOX, R W O'B, and CORDEY, W G (editors). (Nottingham: British Geological Survey.)

JUDD, J W. 1878. The secondary rocks of Scotland. Third paper. The strata of the Western Coast and Islands. With a note on the foraminifera and other organisms in the Chalk of the Hebrides by T R Jones. *Quarterly Journal of the Geological Society of London*, Vol. 34, 600–743.

JUDD, J W. 1867. On the strata which form the base of the Lincolnshire Wolds. *Quarterly Journal of the Geological Society of London*. Vol. 23, 227–251.

JUIGNET, P, and BRETON, G. 1994. Stratigraphie, rhythmes sedimentaires, et eustatisme dans les craies Turoniennes de la region de Fécamp (Seine-Maritime, France). *Bulletin trimestrielle de la Societé Géologique et Amis Muséum du Havre*, Vol. 81, 55–81.

JUKES-BROWNE, A J. 1875. On the relations of the Cambridge Gault and Greensand. *Quarterly Journal of the Geological Society of London*, Vol 31, 256–316.

JUKES-BROWNE, A J. 1880. On the subdivisions of the Chalk. *Geological Magazine*, Vol. 17, 248–257.

JUKES-BROWNE, A J. 1887. Notes on a bed of Red Chalk in the Lower Chalk of Suffolk. *Geological Magazine*, Vol. 34, p. 24.

JUKES-BROWNE, A J. 1889. The Geology of Upton and Chilton, in Berks. *Proceedings of the Geologists' Association*, Vol. 11, 198–209.

JUKES-BROWNE, A J, and HILL, W. 1887. On the lower part of the Upper Cretaceous Series in west Suffolk and Norfolk. *Quarterly Journal of the Geological Society of London*, Vol. 43, 544–598.

JUKES-BROWNE, A J, and HILL, W. 1889. The occurrence of colloid silica in the Lower Chalk of Berkshire and Wiltshire. *Quarterly Journal of the Geological Society of London*, Vol. 45, p. 40.

JUKES-BROWNE, A J, and HILL, W. 1896. A delimitation of the Cenomanian:- being a comparison of the corresponding beds in south-western England and western France. *Quarterly Journal of the Geological Society*, Vol. 52, 99–177.

JUKES-BROWNE, A J, and HILL, W. 1900. The Cretaceous Rocks of Britain, Volume I. The Gault and Upper Greensand of England. *Memoirs of the Geological Survey of the United Kingdom*.

JUKES-BROWNE, A J, and HILL, W. 1903. The Cretaceous Rocks of Britain. II. The Lower and Middle Chalk of England. *Memoirs of the Geological Survey of the United Kingdom*.

JUKES-BROWNE, A J, and HILL, W. 1904. The Cretaceous rocks of Britain, III. The Upper Chalk of England. *Memoir of the Geological Survey of the United Kingdom*.

KELLY, S R A, and RAWSON, P F. 1983. Some late Jurassic – mid-Cretaceous sections on the East Midlands Shelf, England, as demonstrated on a Field Meeting, 18–20 May 1979. *Proceedings of the Geologists' Association*, Vol. 94, 65–73.

KENNEDY, W J. 1969. The correlation of the Lower Chalk of south-east England. *Proceedings of the Geologists' Association*, Vol. 80, 459–551.

KENNEDY, W J. 1970. A correlation of the uppermost Albian and the Cenomanian of south-west England. *Proceedings of the Geologists' Association*, Vol. 81, 613–677.

LAMPLUGH, G W. 1895. Notes on the White Chalk of Yorkshire. Parts I and II. *Proceedings of the Yorkshire Geological and Polytechnic Society*, Vol. 13. 171–191.

LAKE, R D, YOUNG, B, WOOD, C J, and MORTIMORE, R N. 1987. Geology of the country around Lewes. *Memoir of the British Geological Survey*, Sheet 319 (England and Wales).

LEE, G W, and BAILEY, E B. 1925. The pre-Tertiary Geology of Mull, Loch Aline and Oban. *Memoir of the Geological Survey of Great Britain*, parts of Sheets 35, 43, 44, 45 and 52 (Scotland).

LEE, G W, and PRINGLE, J. 1932. A Synopsis of the Mesozoic Rocks of Scotland. *Transactions of the Geological Society of Glasgow*, Vol. 19, 158–224.

LOTT, G K, and KNOX R W O'B. 1994. Post Triassic of the Southern North Sea. Volume 7 in *Lithostratigraphic nomenclature of the UK North Sea*. Knox, R W O'B, and CORDEY, W G (editors). (Nottingham: British Geological Survey.)

LOWDEN, B, BRALEY, S, HURST, A, and LEWIS, J. 1992. Sedimentological studies of the Cretaceous Lochaline Sandstone, NW Scotland. 159–162 *in* Basins on the Atlantic Seaboard: Petroleum Geology, Sedimentology and Basin Evolution. PARNELL, J (editor). *Geological Society of London Special Publication*, No. 62.

MANNING, P I, ROBBIE, J H, and WILSON, H E. 1970. Geology of Belfast and the Lagan Valley. *Memoir of the Geological Survey of Northern Ireland*, Sheet 36 (Northern Ireland).

MANTELL, G A. 1822. *The Fossils of the South Downs* or *Illustrations of the Geology of Sussex*. (London: Lepton Relfe).

MEYER, C J A. 1874. On the Cretaceous rocks of Beer Head and the adjacent cliffs, and of the relative horizons therein of the Warminster and Blackdown fossiliferous deposits. *Quarterly Journal of the Geological Society*, Vol. 30, 369–393.

MITCHELL, S F. 1994. New data on the biostratigraphy of the Flamborough Chalk Formation (Santonian, Upper Cretaceous) between South Landing and Danes Dyke, North Yorkshire. *Proceedings of the Yorkshire Geological Society*, Vol. 50, 113–118.

MITCHELL, S F. 1995a. Lithostratigraphy and biostratigraphy of the Hunstanton Formation (Red Chalk, Cretaceous) succession at Speeton, North Yorkshire. *Proceedings of the Yorkshire Geological Society*, Vol. 50, 285–303.

MITCHELL, S F. 1995b. *Uintacrinus anglicus* Rasmussen from the Upper Cretaceous Flamborough Chalk Formation of Yorkshire: implications for the Santonian–Campanian boundary. *Cretaceous Research*, Vol. 16, 745–756.

MITCHELL, S F. 2000. The Welton Formation (Chalk Group) at Speeton NE England: implications for the Late Cretaceous evolution of the Market Weighton structure. *Proceedings of the Yorkshire Geological Society*, Vol. 53, 17–24.

MORTIMORE, R N. 1983. The stratigraphy and sedimentation of the Turonian–Campanian in the southern province of England. *Zitteliana*, Vol. 10, 27–41.

MORTIMORE, R N. 1986. Stratigraphy of the Upper Cretaceous White Chalk of Sussex. *Proceedings of the Geologists' Association*, Vol. 97, 97–139.

MORTIMORE, R N. 1987. Upper Cretaceous Chalk in the North and South Downs, England; a correlation. *Proceedings of the Geologists' Association*, Vol. 98, 77–86.

MORTIMORE, R N. 1988. Upper Cretaceous White Chalk in the Anglo-Paris Basin: a discussion of lithological units. *Proceedings of the Geologists' Association*, Vol. 99, 67–70.

MORTIMORE, R N, and POMEROL, B. 1987. Correlation of the Upper Cretaceous White Chalk (Turonian to Campanian) in the Anglo-Paris Basin. *Proceedings of the Geologists' Association*, Vol. 98, 97–143.

MORTIMORE, R N, and POMEROL, B. 1996. A revision of Turonian litho- and biostratigraphy in the Anglo-Paris Basin. *Mittelungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg*, Vol. 77, 423–441.

MORTIMORE, R N, and POMEROL, B and, FOORD, R J. 1990. Engineering stratigraphy and palaeogeography for Chalk of the Anglo-Paris Basin. 47–62 in *Chalk*. BURLAND, J B MORTIMORE, R N, ROBERTS, L D, JONES, D L, and CORBETT, B O (editors). (London: Thomas Telford.)

MORTIMORE, R N, and WOOD, C J. 1986. The distribution of flint in the English Chalk, with particular reference to the 'Brandon Flint Series' and the high Turonian flint maximum. 7–20 in *The Scientific Study of Flint and Chert*. SIEVEKING, G DE G, and HART, M B (editors). (Cambridge: Cambridge University Press.)

MORTIMORE, R N, and WOOD, C J, and GALLOIS, R W. 2001. British Upper Cretaceous Stratigraphy. (Peterborough: Joint Nature Conservation Committee). *Geological Conservation Review Series*, No. 23.

MURRAY, K H. 1986. Correlation of electrical resistivity marker bands in the Cenomanian and Turonian Chalk from the London Basin to East Yorkshire. *British Geological Survey Report*, Vol. 17, No. 8, 1–18.

NEALE, J W. 1974. The Cretaceous. 325–384 in *A Stratigraphical Index of British Ostracods*. BATE, R, and ROBINSON (editors). (London: Ellis Horwood.)

OWEN, H G. 1995. The upper part of the Carstone and the Hunstanton Red Chalk (Albian) of the Hunstanton Cliff, Norfolk. *Proceedings of the Geologists' Association*, Vol. 106, 171–181.

PEAKE, N B, and HANCOCK, J M. 1961. The Upper Cretaceous of Norfolk. *Transactions of the Norwich and Norfolk Naturalists Society*. Vol. 19, 293–339.

PEAKE, N B, and HANCOCK, J M. 1970. The Upper Cretaceous of Norfolk [reprinted with corrigenda and addenda with new map]. 293–339 in The Geology of Norfolk, LARWOOD, G P, and FUNNEL, B M (editors). (Norwich: Soman-Wherry Press.)

PENNING, W H, and JUKES-BROWNE, A J. 1881. Geology of the neighbourhood of Cambridge. *Memoirs of the Geological Survey of England and Wales*, Explanation of Old Series quarter-sheet 51SW and part of 51 NW (England and Wales).

PHILLIPS, J. 1829. *Illustrations of the Geology of Yorkshire*, or a *Description of the Strata and Organic Remains of the Yorkshire Coast*. (York: Thomas Wilson and Sons.) (First edition). (Second Edition, 1835; Third Edition, 1875).

PHILLIPS, W. 1818. *A selection of facts from the best authorities arranged so as to form an outline of the geology of England and Wales*. (London: William Phillips.)

PHILLIPS, W. 1821. Remarks on the Chalk cliffs in the neighbourhood of Dover, and on the Blue Marle covering the Green Sand, near Folkestone. *Transactions of the Geological Society of London*, Vol. 5, 16–51.

PORTLOCK, J E. 1843. *Report on the geology of the County of Londonderry and parts of Tyrone and Fermanagh*. (Dublin: HMSO.)

PRICE, F G H. 1877. On the beds between the Gault and Upper Chalk near Folkestone. *Quarterly Journal of the Geological Society of London*, Vol. 33, 431–48.

RASMUSSEN, H W. 1961. A monograph on the Cretaceous Crinoidea. *Det Kongelige Danske Videnskabernes Seskab, Biologiske Skrifter*, Vol. 12, 1–248.

RAWSON, P F. 1992. The Cretaceous. 355–388 in *The Geology of England and Wales*. DUFF, P MCL D, and SMITH, A J (editors). (London: Geological Society.)

RAWSON, P F, ALLEN, P M, and GALE, A S. 2001. The Chalk Group – a revised lithostratigraphy. *Geoscientist*, Vol. 11, p.21.

RAWSON, P F, CURRY, D, DILLEY, F C, HANCOCK, J M, KENNEDY, W J, NEALE, J W, WOOD, C J, and WORSSAM, B C. 1978. A correlation of Cretaceous rocks in the British Isles. *Geological Society of London*, *Special Report* No. 9.

RAWSON, P F, and WITHAM, F. 1992. Itinery XI and XII. 94–103 in *The Yorkshire Coast*. RAWSON, P F, and WRIGHT, J K. GREENSMITH, J T (editors). (Field Guide No. 34 (2nd Edition). (London: Geologists, Association.)

REID, R E H. 1958. Remarks on the Upper Cretaceous Hexatinellida of County Antrim. *The Irish Naturalists' Journal*, Vol. 12, 263–268.

REID, R E H. 1964. The lower (pre-*Belemnitella mucronata*) White Limestone of the east and north-east of County Antrim. *Irish Nauralists' Journal*, Vol. 14, 262–269, 296–303.

REID, R E H. 1971. The Cretaceous rocks of north-eastern Ireland. *Irish Naturalists' Journal*, Vol. 17, 105–129.

RHYS, G H. 1974. A proposed standard lithostratigraphic nomenclature for the Southern North Sea and an outline structural nomenclature for the whole of the (UK) North Sea. A report of the Joint Oil Industry – Institute of Geological Sciences Committee on North Sea Nomenclature. *Report of the Institute of Geological Sciences*, No. 74/8.

RITCHIE, J D, GATLIFF, R W, and RIDING, J B. 1996. 1. Pre-Tertiary lithostratigraphy. In *Stratigraphic Nomenclature of the UK North West Margin*. (Nottingham: British Geological Survey.)

ROBASZYNSKI, F, and AMEDRO, F. 1986. The Cretaceous of the Boulonnais, France, and a comparison with the Cretaceous of Kent (United Kingdom). *Proceedings of the Geologists' Association*, Vol. 97, 171–208.

ROBASZYNSKI, F, JUIGNET, P, GALE, A S, AMEDRO, F, and HARDENBOL, J. 1998. Sequence stratigraphy in the Cretaceous of the Anglo-Paris Basin, exemplified by the Cenomanian Stage. 363–386 in *Mesozoic and Cenozoic Sequence Stratigraphy of European Basins*. GRACIANSKY, P-C DE, HARDENBOL, J, JAQUIN, T, and VAIL, P R (editors). Society for Sedimentary Geology Special Publication No. 60, (Tulsa, Oklahoma: SEPM.)

ROBINSON, N D. 1986, Lithostratigraphy of the Chalk Group, North Downs, Southeast England. *Proceedings of the Geologists' Association*, Vol. 97, 141–70.

ROBINSON, N D. 1987. Upper Cretaceous Chalk in the North and South Downs, England: a reply. *Proceedings of the Geologists' Association*, Vol. 98, 87–93.

ROWE, A W. 1899. An analysis of the genus *Micraster*, as determined by rigorous zonal collecting from the zone of *Rhynchonella cuvieri* to that of *Micraster coranguinum*. *Quarterly Journal of the Geological Society of London*, Vol. 55, 495–547.

ROWE, A W. 1900. The zones of the White Chalk of the English Coast. I. Kent and Sussex. *Proceedings of the Geologists' Association*, Vol. 16, 289–368.

ROWE, A W. 1901. The zones of the White Chalk of the English Coast. II. Dorset. *Proceedings of the Geologists' Association*, Vol. 17, 1–76.

ROWE, A W. 1903. The zones of the White Chalk of the English Coast. III. Devon. *Proceedings of the Geologists' Association*, Vol. 18, 1–51.

ROWE, A W. 1904. The zones of the White Chalk of the English Coast. IV. Yorkshire. *Proceedings of the Geologists' Association*, Vol. 18, 193–296.

ROWE, A W. 1908. The zones of the White Chalk of the English coast. V. The Isle of Wight. *Proceedings of the Geologists' Association*, Vol. 20, 209–350.

SAMPSON, G V. 1814. *A Memoir explanatory of the Chart and Survey of the County of Londonderry, Ireland*. (Pall Mall, London: G and W Nicol.)

SCOTT, J F. 1928. General geology and physiography of Morvern, Argyll. *Transactions of the Geological Society of Glasgow*, Vol. 18, 149–189.

SEELEY, H. 1866. The rock of the Cambridge Greensand. *Geological Magazine*, Vol. 3, 302–307.

SHARPE, D. 1853. Description of the fossil remains of Mollusca found in the Chalk of England. Part 1. Cephalopoda. *Palaeontographical Society Memoir*, 1–70.

SHEPARD-THORN, E R. 1988. Geology of the country around Ramsgate and Dover. *Memoir of the British Geological Survey*, Sheets 274 and 290 (England and Wales).

SHEPARD-THORN, E R, MOORLOCK, B S P, COX, B M, ALLSOP, J M, and WOOD, C J. 1994. Geology of the country around Leighton Buzzard. *Memoir of the British Geological Survey*, Sheet 220 (England and Wales).

SKERTCHLY, S B J. 1879. *On the manufacture of gun-flints, the methods of excavation for flint, the age of Palaeolithic man and the connexion between Neolithic art and the gun-flint trade*. (London: HMSO.)

SMITH, W E. 1957. The Cenomanian Limestone of the Beer District, South Devon. *Proceedings of the Geologists' Association*, Vol. 68, 115–135.

SMITH, W E. 1965. The Cenomanian deposits of south-east Devonshire. The Cenomanian Limestone east of Seaton. *Proceedings of the Geologists' Association*, Vol. 76, 121–36.

SUMBLER, M G. 1996. The stratigraphy of the Chalk Group of Yorkshire, Humberside and Lincolnshire. *British Geological Survey Technical Report*, WA/96/26C.

SUMBLER, M B. 1999. The stratigraphy of the Chalk Group of Yorkshire, and Lincolnshire. *British Geological Survey Technical Report*, WA/99/02.

SURLYK, F, DONS, T, CLAUSEN, C K, and HIGHAM, J. 2003. Upper Cretaceous. 213–233 in *The Millennium Atlas: petroleum geology of the central and northern North Sea*. EVANS, D, GRAHAM, C, ARMOUR, A, and BATHURST, P (editors and co-ordinators). (London: The Geological Society of London.)

TATE, R. 1865. On the correlation of the Cretaceous formations of north-east Ireland. *Quarterly Journal of the Geological Society of London*, Vol. 21, 15–44.

WHITAKER, W. 1861. On the Chalk-Rock, the topmost bed of the Lower Chalk in Berkshire, Oxfordshire and Buckinghamshire. *Quarterly Journal of the Geological Society of London*, Vol. 17, 166–170.

WHITAKER, W. 1865a. On the Chalk of the Isle of Thanet. *Quarterly Journal of the Geological Society of London*, Vol. 21, 395–8.

WHITAKER, W. 1865b. On the Chalk of Buckinghamshire, and on the Totternhoe Stone. *Quarterly Journal of the Geological Society of London*, Vol. 21, 398–400.

WHITAKER, W. 1872. The geology of the London Basin: Part 1 the Chalk and Eocene beds of the southern and western tracts. *Memoir of the Geological Survey of Great Britain*.

WHITAKER, W, BRISTOW, H W, and HUGHES, T M. 1872. The geology of the London Basin. Part 1. The Chalk and Eocene beds of the southern and western tracts. *Memoir of the Geological Survey of England and Wales*.

WHITE, H J O. 1923. The Geology of the country south and west of Shaftsbury. *Memoir of the Geological Survey of Great Britain*, Sheet 313 (England and Wales).

WHITEHURST, J. 1786. *An inquiry into the original state and formation of the Earth; deduced from facts and the laws of nature*. 2nd Edition, (London: W Bent.).

WILSON, H E. 1972. *The regional geology of Northern Ireland*. (Belfast: HMSO for Geological Survey of Northern Ireland.)

WILSON, H E, and ROBBIE, J A. 1966. Geology of the country around Ballycastle. *Memoir of the Geological Survey of Northern Ireland*, Sheet 8 (Northern Ireland).

WITHAM, F. 1991 The stratigraphy of the Upper Cretaceous Ferriby, Welton and Burnham formations north of the Humber, north-east England. *Proceedings of the Yorkshire Geological Society*, Vol. 48, 227–254.

WITHAM, F. 1992. Itinerary XIII. South Landing to Sewerby. 103–109 in *The Yorkshire Coast*. RAWSON, P F, and WRIGHT, J K, GREENSMITH, J T (editor). Field Guide No. 34 (2nd Edition) (London: Geologists' Association.)

WITHAM, F. 1993. The stratigraphy of the Upper Cretaceous Flamborough Chalk Formation north of the Humber, north-east England. *Proceedings of the Yorkshire Geological Society*, Vol. 49, 235–258.

WOLFE, M J. 1968. Lithification of a carbonate mud: Senonian Chalk in Northern Ireland. *Sedimentary Geology*, Vol. 2, 263–290.

WOOD, C J. 1967. Some new observations on the Maestrichtian Stage in the British Isles. *Bulletin of the Geological Survey of Great Britain*, Vol. 27, 271–288.

WOOD, C J. 1980. Upper Cretaceous. 92–105 in *British regional geology: Eastern England from the Tees to the Wash*. (2nd Edition). Kent, P E (London: HMSO for the Institute of Geological Sciences.)

WOOD, C J, BATTEN, D J, MORTIMORE, R N, and WRAY, D S. 1997. The stratigraphy and correlation of the Cenomanian–Turonian boundary interval succession in Lincolnshire, northern England. *Freiberger Forschungsheft, Reihe C*, Vol. 468, 333–346.

WOOD, C J, and MORTIMORE, R N. 1995. An anomalous Black Band succession (Cenomanian–Turonian boundary interval) at Melton Ross, Lincolnshire, eastern England and its international significance. *Berliner geowissenschaftliche Abhandlungen, Reihe E*, Vol. 16, 277–287.

WOOD, C J, MORTER, A A, and GALLOIS, R W. 1994. Appendix 1. Upper Cretaceous stratigraphy of the Trunch Borehole (TG 23 SE 8). 105–110 in Geology of the country around Great Yarmouth. ARTHURTON, R S, BOOTH, S J, MORIGI, A N, ABBOTT, M A W, and WOOD, C J. *Memoir of the British Geological Survey*, Sheet 162 (England and Wales).

WOOD, C J, and SMITH, E G. 1978. Lithostratigraphical classification of the Chalk in North Yorkshire, Humberside and Lincolnshire. *Proceedings of the Yorkshire Geological Society*, Vol. 42, 263–287.

WOODWARD, S. 1831. An outline of the Geology of Norfolk. (Norwich: John Stacy and London: Longman and Co.)

WORSSAM, B C, and TAYLOR, J H. 1969. The geology of the country around Cambridge. *Memoir of the Geological Survey of Great Britain*, Sheet 188 (England and Wales).

WRIGHT, C W. 1963. The Cretaceous. 30–34 in *Geology of the Yorkshire Coast*, RAINE, G T (editor). Field Guide No. 34 (1st Edition) (London: Geologists' Association.)

WRIGHT, C W. 1968. Itinerary IX. Reighton Gap to Speeton Cliffs. 39–44 in *Geology of the Yorkshire Coast*, HEMINGWAY, J E, WILSON, V, and WRIGHT, C W. HESTER, S W (editors). Field Guide No. 34 (Revised 1st Edition). (London: Geologists' Association.)

WRIGHT, C W, and WRIGHT, E V. 1942. The Chalk of the Yorkshire Wolds. *Proceedings of the Geologists' Association*, Vol. 53, 112–127.

YOUNG, B, and LAKE, R D. 1988. Geology of the country around Brighton and Worthing. *Memoir British Geological Survey*, Sheets 318 and 333 (England and Wales).

Appendix 1 — BGS geological sheet areas in England and Scotland showing Upper Cretaceous strata

This list encompasses all of the Geological Survey sheets within Great Britain with units of the Upper Cretaceous delimited. The 'date' indicates the published date of the latest edition, though in many cases the date of survey is much earlier. Provisional editions (P) are based principally on a desk revision incorporating available data. The Chalk nomenclature schemes used to divide the rocks are given as follows:- Scotland Traditional (ST); England and Wales Traditional (EWT); England and Wales Revised (EWR); England and Wales fully compliant with agreed terminology (EWFC); [Northern Province (NP); Southern Province (SP)]. An indication of the upgrading of terminology required to conform to the framework herein is indicated in the notes column. The PDG Programme was the 10-year forward look for the BGS surveying programme, until 2005. It was replaced by a new programme in April 2005. OOP indicate sheets out of print.

Terminological schemes used on 1:50 000 geological maps in Scotland.

Sheet name	Sheet No.	Date	Scheme used	Notes
Iona	S43	1954	ST	Minor name revision
Staffa (P)	S43N	1996	ST	Minor name revision
Ross of Mull	S43S	1999	ST	Minor name revision
Eastern Mull	S44W/ pt.44E	1992	ST	Reprinted without revision
Lismore	S44E	1992	ST	Reprinted without revision
Ardnamurchan	S52W	1977	ST	Minor name revision
Strontian	S52E	1977	ST	Minor name revision
Rum	S60	1994	ST	Minor name revision
Minginish	S70	2001	ST	Minor name revision
Minginish	S70	1964	ST	Minor name revision
Broadford	S71W	1976	ST	Minor name revision

Terminological schemes used on 1:50 000 geological maps in England.

Sheet name	Sheet No.	Date	Scheme used	Notes
Pickering (P)	53	2001	EWRNP	Minor revision required
Scarborough (P)	54	1998	EWRNP	Minor revision required
Flamborough & Bridlington (P)	55/65	1986	EWRNP	Minor revision required
York	63	1983	EWT	In PDG programme
Great Driffield (P)	64	1993	EWRNP	Minor revision required
Selby	71	1973	EWT	In PDG programme
Beverley (P)	72	1995	EWRNP	Minor revision required
Hornsea (P)	73	1998	EWRNP	Minor revision required
Kingston upon Hull	80	1983	EWRNP	Minor revision required
Patrington	81/82 pt 90	1991	EWRNP	Minor revision required
Brigg	89	1982	EWRNP	Minor revision required
Grimsby	90/91	1990	EWRNP	Minor revision required
Louth (P)	103	1999	EWRNP	Minor revision required
Mablethorpe (P)	104	1996	EWRNP	Minor revision required
Horncastle (P)	115	1995	EWRNP	Minor revision required
Skegness (P)	116	1996	EWRNP	Minor revision required
The Wash	129	1997	EWT	Revision required
Wells-next-the-Sea	130	OOP	EWT	In PDG programme
Cromer	131	2003	EWFCSP	Compliant to formation
Mundelsey & Walsham	132 & 148	1998	EWT concealed	Nomenclature revision required
King's Lynn & The Wash	145/pt 129	1978	EWT	Nomenclature revision required
Fakenham (P)	146	1999	EWRSP	Minor revision required
Aylesham	147	OOP	EWT	In PDG programme
Wisbech	159	1995	EWT	Nomenclature revision required
Swaffham (P)	160	1998	EWRSP	Minor revision required
Norwich	161	1975	EWT	Nomenclature revision required. In PDG programme
Great Yarmouth	162	1990	EWT concealed	Nomenclature revision required
Ely	173	1980	EWT	Nomenclature revision required

Terminological schemes used on 1:50 000 geological maps in England (cont).

Sheet name	Sheet No.	Date	Scheme used	Notes
Thetford	174	OOP	EWT	In PDG programme
Diss	175	1989	EWT	Nomenclature revision required
Lowestoft	176	1996	EWFCSP concealed	Compliant at group level
Huntingdon	187	1975	EWT	Nomenclature revision required
Cambridge	188	1981	EWT	Nomenclature revision required
Bury St Edmunds	189	1982	EWT	Nomenclature revision required
Eye (P)	190	1995	EWT	Nomenclature revision required
Saxmundham	191	1996	EWT concealed	Nomenclature revision required
Biggleswade	204	2001	EWRSP	Minor revision required
Saffron Walden	205	2002	EWRSP	Minor revision required
Sudbury	206	1991	EWT	Nomenclature revision required
Ipswich (P)	207	1990	EWT concealed	In PDG programme (2010)
Woodbridge & Felixstowe	208 & 225	2001	EWSP	Minor revision required
Leighton Buzzard	220	1992	EWT	Nomenclature revision required
Hitchin	221	1995	EWT	Nomenclature revision required
Great Dunmow	222	1990	EWT	Minor revision required
Braintree	223	1982	EWT concealed	Minor revision required
Colchester	224	OOP	EWT concealed	Minor revision required
Thame	237	1994	EWT	Nomenclature revision required
Aylesbury	238	1923	EWT	Nomenclature revision required. In PDG programme
Hertford	239	1978	EWT	Nomenclature revision required. In PDG programme
Epping	240	1981	EWT concealed	Nomenclature revision required
Chelmsford	241	1975	EWT concealed	Nomenclature revision required
Swindon	252	1974	EWT	Nomenclature revision required
Abingdon	253	1971	EWT	Nomenclature revision required
Henley-on-Thames	254	1980	EWT	Nomenclature revision required
Beaconsfield	255	2005	EWFCSP	New sheet
North London	256	1994	EWT	Nomenclature revision required
Romford	257	1996	EWT concealed	Nomenclature revision required
Southend & Foulness	258/259	1976	EWT concealed	Nomenclature revision required
Marlborough	266	1974	EWT	Nomenclature revision required. In PDG programme
Newbury (Hungerford)	267	1947*	EWT	Nomenclature revision required. *New sheet in press 2005 (EWFCSP)
Reading	268	2000	EWRSP	Minor revision required
Windsor	269	1999	EWRSP	Nomenclature revision required
South London	270	1998	EWT	Nomenclature revision required
Dartford	271	1998	EWRSP	Minor revision required
Chatham	272	1977	EWT	Nomenclature revision required. In PDG programme (2008)
Faversham	273	1974	EWT	Nomenclature revision required. In PDG programme (2010)
Ramsgate	274	1980	EWT	Nomenclature revision required
Frome	281	2001	EWRSP	Minor revision required
Devizes	282	1959	EWT	Nomenclature revision required. In PDG programme (2005)
Andover	283	1975	EWT	Nomenclature revision required. In PDG programme (2007)
Basingstoke	284	1978	EWT	Nomenclature revision required. In PDG programme (2008)
Guildford	285	2001	EWRSP	minor revision required
Reigate	286	1978*	EWT	*New sheet in press, minor revision
Sevenoaks	287	1971	EWT	In PDG programme
Maidstone	288	1976	EWT	Nomenclature revision required
Canterbury	289	1982	EWT	Nomenclature revision required
Dover	290	1977	EWT	Nomenclature revision required
Wincanton	297	1996	EWRSP	Minor revision required
Salisbury	298	2005	EWFCSP	New sheet
Winchester	299	2002	EWFCSP	New sheet
Alresford	300	2000	EWRSP	Minor revision required

Terminological schemes used on 1:50 000 geological maps in England (cont).

Sheet name	Sheet No.	Date	Scheme used	Notes
Folkestone & Dover	305 &306	1974	EWT	Nomenclature revision required
Wellington	311	1976	EWT	Nomenclature revision required. In PDG programme
Yeovil	312	1958	EWT	Nomenclature revision required
Shaftsbury	313	1994	EWRSP	Minor revision required
Ringwood	314	2004	EWFCSP	New sheet
Southampton	315	1987	EWT	Nomenclature revision required
Fareham	316	1998	EWRSP	Minor revision required
Chichester & Bognor	317 & 332	1996	EWRSP	Minor revision required
Brighton & Worthing	318 & 333	1984*	EWT	*New sheet in press 2005 (EWFCSP)
Lewes/Eastbourne	319/334	1979*	EWT	*New sheet in press 2005/6 (EWFCSP)
Sidmouth	326 & 340	2005	EWFCSP	New sheet
Bridport	327	1977	EWT	Nomenclature revision required. In PDG programme
Dorchester	328	2001	EWRSP	Minor revision required
Bournemouth	329	1991	EWT	Nomenclature revision required
Lymington	330	1975	EWT	Nomenclature revision required. In PDG programme (2009)
Portsmouth	331	1994	EWT	Nomenclature revision required
West Fleet and Weymouth	Pts. 341 & 342	2001	EWRSP	Minor revision required
Swanage	pts 342 & 343	2000	EWFCSP	Minor revision required
Isle of Wight	Pts. 330, 331, 344, & 345	1976	EWT	Nomenclature revision required. In PDG programme (2010)

It should be noted that the BGSs hold all of its 1:50 000 scale geological linework in digital fully attributed format within a dataset called DigMapGB-50. Version 1 was launched in 2002 and had anticipated some nomenclature changes within sheet areas that were being revised prior to that date. Version 2 has been released recently and incorporates many revisions to the Chalk nomenclature and linework. This data will be incorporated into the printed dataset, as new editions, when individual sheets come up for reprinting.

The BGS is also compiling a 1:10 000 scale dataset, DigMapGB-10. At present coverage is restricted to those areas where newly acquired geological linework (since the mid 1990s) is available. This includes a considerable part of the Chalk outcrop particularly in Southern England. The dataset is expanding rapidly as new areas are mapped and where the BGS is commissioned to digitise its historical map dataset held at various scales and projections.

Appendix 2 — Nomenclature terms used on published 1:50 000 scale BGS geological sheets in England and Scotland (S)

This table incorporates all of the terms used to describe and divide the Upper Cretaceous successions shown on the published 1:50 000 scale maps currently available (listed by number). The terms that are recommended for use in the framework described in this report are given in bold. Redundant terms in normal type have been given an equivalent term within the framework, where such a term is discernible and meaningful. It is recommended that these replacement terms are used when maps come up for revision.

Terms used on BGS 1:50 000 geological maps in England and Scotland (S).

Term used	**50K sheet number (s) on which term appears**	**Equivalent term in framework**
Blandford Chalk	313	Seaford Chalk and Newhaven Chalk formations undivided
Brandon Flint Series	175	Bed or member as yet undefined within the Lewes Nodular Chalk Formation
Burnham Chalk	55 & 65, 80, 81 & 82 and pt 90, 89, 90 & 91	**Burnham Chalk Formation**
Burnham Formation	73, 103	Burnham Chalk Formation
Cambridge Greensand	173, 175, 187, 188, 189, 204, 205, 206, 221	**Cambridge Greensand Member** Equivalent to the Melbury Sandstone Member and the Glauconitic Marl Member
Cenomanian Greensand	S52E, S52E, S43, S44	**Morvern Greensand Formation**
Chalk	208 & 225, 256, 331	Chalk Group
Chalk (Flamborough, Burnham and Welton Chalks), undifferentiated	104	The major part of the White Chalk Subgroup
Chalk Group	257, 268, 269, 281, 297, 299, 300, 313, 316, 317 & 332, 328, 341 & 342, 343 & 342	**Chalk Group** defined within the Northern and Southern provinces in England
Chalk Group, undivided	176	Chalk Group defined within the Northern and Southern provinces in England
Chalk Marl	187, 267, 283, 284	Part of the Grey Chalk Subgroup. All of the West Melbury Marly Chalk Formation and the lower part of the Zig Zag Chalk Formation
Chalk Rock	175, 188, 189, 204, 205, 206, 220, 221, 237, 238, 239, 253, 254, 267, 282, 283, 312, 327, 331	**Chalk Rock Member**, part of the Lewes Nodular Chalk Formation
Chalk with flints (Middle Chalk)	63	Equivalent to part of the Welton Chalk Formation and Burnham Chalk Formation
Chalk without flints (Lower Chalk)	63	Equivalent to the Ferriby Chalk Formation and the lowest part of the Welton Chalk Formation
Chilton Stone	253	Equivalent to the Totternhoe Stone Member of the Zig Zag Chalk Formation
Culver Chalk Formation	299, 314, 343 & 342	**Culver Chalk Formation**. Includes the Tarrant Chalk Member and the Spetisbury Chalk Member where these are discernible
Ferriby Chalk	55 & 65, 80, 81 & 82 pt 90, 89, 90 & 91, 104,116	Ferriby Chalk Formation
Ferriby Chalk Formation	54, 64, 72, 115	**Ferriby Chalk Formation**
Ferriby Formation	73, 103	Ferriby Chalk Formation
Flamborough Chalk	55 & 65, 80, 81 & 82 pt 90, 90 & 91	Flamborough Chalk Formation

Terms used on BGS 1:50 000 geological maps in England and Scotland (S) (cont).

Term used	50K sheet number (s) on which term appears	Equivalent term in framework
Flamborough Chalk Formation	54, 64, 72	**Flamborough Chalk Formation**
Flamborough Formation	73	Flamborough Chalk Formation
Glauconitic Marl	237, 254, 289, 299, 300, 316, 317 & 332	**Glauconitic Marl Member** of the West Melbury Marly Chalk Formation
Glauconitic sandstone (≡ Greensand)	S43N, S43S	Morvern Greensand Formation
Grey Chalk Subgroup	299, 314	**Grey Chalk Subgroup**. Includes the Zig Zag Chalk Formation and the West Melbury Marly Chalk Formation in the Southern Province; is equivalent to the Ferriby Chalk Formation in the Northern Province
Hard Bed	328	Informally named part of the Newhaven Chalk Formation
Holywell Chalk	271, 313	Holywell Nodular Chalk Formation, originally excluded the Plenus Marls Member
Holywell Nodular Chalk	297, 300, 316, 317 & 332	Holywell Nodular Chalk Formation, originally excluded the Plenus Marls Member
Holywell Nodular Chalk Formation	204, 205, 281, 299, 314, 328, 341 & 342, 343 & 342	**Holywell Nodular Chalk Formation**. Includes the Plenus Marls Member and the Melbourn Rock Member
Horizon of Chalk Rock	284, 286	Chalk Rock Member, part of the Lewes Nodular Chalk Formation
Hunstanton Chalk Formation	64, 72	Hunstanton Formation no longer part of the Chalk Group
Hunstanton Formation	54	**Hunstanton Formation** no longer part of the Chalk Group
Hunstanton Member	73,103	Hunstanton Formation no longer part of the Chalk Group
Laig Gorge Limestone	S60	Informal term for a bed within the Laig Gorge Sandstone Member equivalent in age to the Lochaline White Sandstone Formation
Lewes Chalk	271,313	Lewes Nodular Chalk Formation
Lewes Nodular Chalk	297	Lewes Nodular Chalk Formation
Lewes Nodular Chalk and Seaford Chalk Members, undifferentiated	205	Undivided Lewes Nodular Chalk and Seaford Chalk formations
Lewes Nodular Chalk Formation	204, 299, 314, 343 & 342	**Lewes Nodular Chalk Formation**. Includes the Chalk Rock Member
Lewes Nodular Chalk Member	268, 281, 300, 316, 317 & 332, 328, 341 & 342	Lewes Nodular Chalk Formation
Loch Aline Glass Sand (Loch Aline)	S44W pt 44E, S44E	**Lochaline White Sandstone Formation**
Lower Beds (Chalk Marl)	188	Equivalent to the West Melbury
Marly Chalk Formation		Equivalent to the Grey Chalk
Lower Chalk	53, 129, 132 & 148, 145 & pt 129, 159, 161, 162, 173, 175, 187, 188, 189, 190, 206, 207, 220, 221, 222, 237, 238, 239, 240, 252, 253, 254, 257, 266, 267, 268, 269, 270, 271, 272, 273, 274, 282, 283, 284, 286, 287, 288, 289, 290, 297, 300, 305 & 306, 311, 312, 313, 315, 316, 317 & 332, 318 & 333, 319, 327, 329, 330, 331, 334	Subgroup (West Melbury Marly Chalk Formation and Zig Zag Formation) with the inclusion of the Plenus Marls Member of the succeeding Holywell Nodular Chalk Formation

Terms used on BGS 1:50 000 geological maps in England and Scotland (S) (cont).

Term used	50K sheet number (s) on which term appears	Equivalent term in framework
Lower Chalk (grey chalk)	284	Equivalent to the Grey Chalk Subgroup with the inclusion of the Plenus Marls Member of the succeeding Holywell Nodular Chalk Formation
Lower Chalk Formation	146, 160, 204, 205, 281, 328, 341 & 342	Equivalent to the Grey Chalk Subgroup with the inclusion of the Plenus Marls Member of the succeeding Holywell Nodular Chalk Formation
Lower Chalk without flint	71, 327	Equivalent to the Ferriby Chalk Formation and the lowest part of the Welton Chalk Formation on 71. Equivalent to the Grey Chalk Subgroup with the inclusion of the Plenus Marls Member on 327
Melbourn Rock	129, 145 & pt 129, 175, 188, 189, 204, 205, 206, 220, 221, 237, 238, 252, 253, 254, 267, 282, 283, 284, 285, 286, 287, 288, 289, 305 & 306, 312, 318 & 333, 319, 331, 334	Melbourn Rock Member of the Holywell Nodular Chalk Formation
Melbourn Rock Member	299, 314	Melbourn Rock Member of the Holywell Nodular Chalk Formation
Melbourne Rock	272, 273	Melbourn Rock Member of the Holywell Nodular Chalk Formation
Melbury Sandstone	297, 313	Melbury Sandstone Member of the West Melbury Marly Chalk Formation. Equivalent to the Glauconitic Marl Member. Initially attributed to the Upper Greensand Formation
Melbury Sandstone Member	281	Melbury Sandstone Member of the West Melbury Marly Chalk Formation. Equivalent to the Glauconitic Marl Member. Initially attributed to the Upper Greensand Formation
Middle Chalk	129, 132 & 148, 145 & 129 161, 162, 175, 188, 189, 190, 206, 207, 221, 222, 223, 237, 238, 239, 240, 252, 253, 254, 257, 266, 267, 268, 269, 270, 271, 272, 273, 274, 282, 283, 284, 285, 286, 287, 288, 289, 290, 297, 300, 305 & 306, 311, 312, 313, 315, 316, 317 & 332, 327, 329, 330, 331	Equivalent to the lowest part of the Lewes Nodular Chalk Formation, the New Pit Chalk Formation and the Holywell Nodular Chalk Formation(with the exclusion of the Plenus Marls Member)
Middle Chalk and Lower Chalk	Isle of Wight pts 330, 331, 344, 345	Basal Lewes Nodular Chalk Formation to the base of the Chalk Group
Middle Chalk Formation	146, 160, 204, 205, 281, 328, 341 & 342	Equivalent to the New Pit Chalk Formation and the Holywell Chalk Formation with the exclusion of the Plenus Marls Member
Middle Chalk with flint	71	Lower Burnham Chalk Formation and most of the Welton Chalk Formation
Morvern Greensand	S44W pt 44E, S44E	Morvern Greensand Formation
Morvern Greensand Formation	S70	**Morvern Greensand Formation**
New Pit Chalk	271, 297, 313	New Pit Chalk Formation
New Pit Chalk Member	204, 205, 281, 300, 316, 317 & 332, 328, 341 & 342	New Pit Chalk Formation

Terms used on BGS 1:50 000 geological maps in England and Scotland (S) (cont).

Term used	50K sheet number (s) on which term appears	Equivalent term in framework
New Pit Chalk Formation	299, 314	**New Pit Chalk Formation**
Newhaven Chalk Formation	299, 314, 343 & 342	**Newhaven Chalk Formation**
Newhaven Chalk Member	300, 316, 317 & 332, 328, 341 & 342	Newhaven Chalk Formation
Plenus Marl	273	**Plenus Marls Member** of the Holywell Nodular Chalk Formation
Portsdown Chalk Formation	299, 314, 343 & 342	**Portsdown Chalk Formation**
Portsdown Chalk Member	316, 317 & 332, 328, 341 & 342	Portsdown Chalk Formation
Red Chalk	53, 55 & 65, 63, 71, 80, 81 & 82 pt 90, 89, 90 & 91, 115, 129, 145 & pt 129, 146	Hunstanton Formation
Red Chalk (Hunstanton Member)	104, 116	Hunstanton Formation
Rowe Formation	73	**Rowe Chalk Formation**
Sandstone and limestone with flint	S44	
Seaford and Newhaven (undivided)	328, 341 & 342, 343 & 342	Seaford Chalk Formation and Newhaven Chalk Formation undivided
Seaford and Newhaven Chalk, undivided		
Seaford Chalk	297	Seaford Chalk Formation
Seaford Chalk Formation	299, 314, 343 & 342	**Seaford Chalk Formation**
Seaford Chalk Member	281, 300, 316, 317 & 332, 328, 341 & 342	Seaford Chalk Formation
Seaford to Spetisbury, undivided	343 & 342	Seaford Chalk, Newhaven Chalk and Culver Chalk formations undivided
Siliceous and glauconitic sandstone	S52W, S52E,	Morvern Greensand Formation
Silicified Chalk	S43	**Gribun Chalk Formation**
Silicified Chalk (≡ Gribun Chalk)	S43N	Gribun Chalk Formation
Silicified limestone with flint (Torosay)	S44W & pt 44E, S44E	Gribun Chalk Formation
Spetisbury Chalk	313	Spetisbury Chalk Member
Spetisbury Chalk Member	299, 314, 316, 317 & 332, 328, 341 & 342, 343 & 342	**Spetisbury Chalk Member** of the Culver Chalk Formation
Stockbridge Rock Member	299	**Stockbridge Rock Member** of the Seaford Chalk Formation
Tarrant and Spetisbury Chalk (undivided)	328	**Culver Chalk Formation**
Tarrant Chalk	313	Tarrant Chalk Member
Tarrant Chalk Member	299, 300, 314, 316, 317 & 332, 328, 341 & 342, 343 & 342	**Tarrant Chalk Member** of the Culver Chalk Formation
Top Rock	204, 206, 220, 221	Top Rock Bed within the Lewes Nodular Chalk Formation
Totternhoe Stone	145 & 129, 173, 175, 188, 189, 204, 205, 206, 220, 221, 237, 254	**Totternhoe Stone Member** at the base of the Zig Zag Chalk Formation
Uintacrinus Band	273	Bed within the Newhaven Chalk Formation (Margate Chalk Member)
Upper and Middle Chalk	241	White Chalk Subgroup excluding the Plenus Marls Member
Upper and Middle Chalk, undivided	318 & 333, 319, 334	White Chalk Subgroup excluding the Plenus Marls Member
Upper Beds	188	Part of the Zig Zag Chalk Formation
Upper Chalk	132&148, 161, 162, 175, 188,189, 190, 191, 206, 207, 220, 221, 222, 223, 237, 238, 239, 240, 253, 254, 257, 266, 267, 268, 269, 270,	Equivalent to most of the Lewes Nodular Chalk Formation (from the base of the Chalk Rock Member) and the succeeding

Terms used on BGS 1:50 000 geological maps in England and Scotland (S) (cont).

Term used	50K sheet number (s) on which term appears	Equivalent term in framework
	271, 272, 273, 274, 282, 283, 284, 285, 286, 287, 288, 289, 290, 297, 300, 305 & 306, 311, 312,313, 315, 316, 317 & 332, 327, 329, 330, 331, IoW pts 330 331 344 345	formations up to the pre-Palaeogene unconformity. Term includes the highest chalks in East Anglia
Upper Chalk Formation	146, 160, 204, 205, 281, 328, 341 & 242	Equivalent to the Lewes Nodular Chalk Formation and the succeeding formations up to the pre-Palaeogene unconformity.
Upper Chalk with flint	71	Equated with the Burnham Chalk Formation
Upper Cretaceous limestone	S71W	Inner Hebrides Group and sandstone
Upper Cretaceous undivided	S43N	Inner Hebrides Group
Welton Chalk	55 & 65,80, 81 & 82 pt 90, 89, 90 & 91,116	Welton Chalk Formation
Welton Chalk Formation	115	**Welton Chalk Formation**
Welton Chalk and Burnham Chalk Formations, undiv	54, 64, 72	
Welton Formation	73, 103	Welton Chalk Formation
West Melbury Chalk	313	West Melbury Marly Chalk Formation
West Melbury Marly Chalk	297	West Melbury Marly Chalk Formation
West Melbury Marly Chalk Member	204, 205, 281, 300, 316, 317 & 332, 328	West Melbury Marly Chalk Formation
West Melbury Marly Chalk Formation	299, 313	**West Melbury Marly Chalk Formation**. Includes the Melbury Sandstone Member, the Glauconitic Marl Member and the Cambridge Greensand Member as its basal unit.
White Chalk Subgroup	299, 314, 343 & 342	**White Chalk Subgroup**. Includes the Lewes Nodular Chalk Formation and formations above in the Southern Province; the Welton Chalk Formation and formations above in the Northern Province
White Sandstone	S43	Lochaline White Sandstone Formation
White Sandstone (≡ Loch Aline GlassSand)	S43N	**Lochaline White Sandstone Formation**
Zig Zag Chalk	297, 313	Zig Zag Chalk Formation
Zig Zag Chalk Member	204, 205, 281, 300, 316, 317 & 332, 328, 341 & 342, 343 & 342	Zig Zag Chalk Formation
Zig Zag Chalk Formation	299, 313	**Zig Zag Chalk Formation**. Includes the Totternhoe Stone Member and Cast Bed as its basal unit.

Appendix 3 — Redundant terms on BGS maps and other schemes used in the Southern Province

There are a number of entries that appear in the BGS Lexicon and within commonly quoted references that need to be understood in terms of the lithostratigraphic framework presented herein. Lexicon style entries are given for terms that have appeared on BGS maps but are now considered to be redundant. A further set of terms from four of the principal references concerned with the definition of the Chalk are also given.

The following entries cover terms utilised on BGS maps and, mostly, those that appear in the Lexicon. For the most part these are now redundant terms and frequently poorly defined with respect to formal lithostratigraphies or unit status. Their closest equivalent term in the new Chalk Stratigraphy is given if possible. They are shown in alphabetical order.

A3.1 BLANDFORD CHALK MEMBER

Name

The term Blandford Chalk Member was used by Bristow et al. (1995) to describe the succession between the Lewes Nodular Chalk and Tarrant Chalk of the Shaftsbury area where they could not distinguish the Seaford Chalk and Newhaven Chalk members.

Type section

General area around Blandford Forum, Dorset.

Primary reference section

Old railway cutting on the military sidings, Blandford, (see Bristow, et al., 1995).

Formal subdivision

None but now regarded as the Seaford and Newhaven Chalk formations undivided.

Lithology

Firm, smooth, white flinty chalk; some thin marl seams present.

Definition of upper boundary

Conformable at the incoming of soft to firm smooth white chalk with conspicuous large flint seams and including the fauna indicative of the *quadrata* zone.

Definition of lower boundary

Conformable at the change from hard nodular chalk, to firm smooth chalk.

Thickness

Between 75 to 90 m in the Shaftsbury area.

Distribution

Confined to the Shaftsbury Geological Sheet 313 area.

Previous names

None but would now be considered to be an amalgamation of the Seaford Chalk Formation and the Newhaven Chalk Formation undivided. Term is redundant except for its use on the Shaftsbury sheet area.

Parent

White Chalk Subgroup.

Age and biostratigraphy

Upper Cretaceous, Coniacian, Santonian and basal Campanian. *Micraster coranguinum* to *Offaster pilula* zones.

References

Barton, 1991; Bristow et al., 1995; Gaster, 1944; Bristow, 1990a; Mortimore, 1986.

A3.2 BRANDON FLINT SERIES

Name

First called the Horizon of the Brandon Flint Series in Hewitt (1935) and used as the Brandon Flint Series in the Bury St Edmunds memoir (Bristow, 1990b).

Type section

Named after Grimes Graves flint mines near Brandon.

Primary reference section

Skertchly (1879) refers to pits at Lingheath (Brandon Park), Santon Downham, Broomhill, Icklingham and Elvedon.

Formal subdivision

None but divided into a number named flint and marl beds.

Lithology

Massive bedded chalks with marl seams and tabular and nodular flints.

Definition of upper boundary

Conformable below the hard yellow nodular chalk of the Chalk Rock.

Definition of lower boundary

Conformable, below the lowest major flint seam (the Rough and Smooth Blacks), which occur below the Grimes Graves Marl. A position that is regarded as marking the base of the *plana* zone.

Thickness

Between 12 and 15 m at Lingheath (Skertchly, 1879; Bristow, 1990b).

Distribution

Central East Anglia around Bury St. Edmunds within the Transitional Province. Its extent is not mapped.

Previous names

Brandon Flints

Parent

Lewes Nodular Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Turonian. *Sternotaxis plana (now Plesiocorys plana)* zone.

References

Skertchly, 1879; Hewitt, 1935; Bristow, 1990b.

A3.3 CHALK MARL

Name

Informal term as part of the terminology for used in the traditional scheme as exemplified in Jukes-Browne and Hill (1903) but in existence prior to that date.

Type section

Folkestone in Kent, Compton Bay on the Isle of Wight.

Primary reference section

See above

Formal subdivision

None but contains some informally named units.

Lithology

Rhythmically bedded marly chalk (argillaceous limestone) and marl (silty calcareous mudstone) with no flint.

Definition of upper boundary

Disconformable beneath the erosion surface at the base of the Totternhoe Stone (see also Chilton Stone) of the Transitional Province as defined by Jukes-Browne and Hill (1903) and its lateral equivalent of the 'Cast Bed' of the Southern Province.

Definition of lower boundary

Conformable at an indistinct horizon at the contact between the 'Chloritic' Marl (Glauconitic Marl) and the Chalk Marl as defined in Jukes-Browne and Hill (1903). In modern usage this would equate to the top of the Glauconitic Marl Member (Southern Province) or the Cambridge Greensand Member (Transitional Province).

Thickness

Generally in the range 15 to 40 m throughout the Southern and Transitional Provinces. Becomes thin or absent in basin margin situations such as the mid-Dorset Swell and in Devon.

Distribution

The term was used widely within the Southern and Transitional provinces to denote the lower part of the Lower Chalk.

Previous names

Longstanding term from the Traditional scheme of Chalk nomenclature, Lower Chalk (Chalk Marl), also referred to as the Lower Beds (Chalk Marl) on the Cambridge Sheet (188). The unit is approximately equivalent to the West Melbury Marl Chalk Formation and the basal Zig Zag Chalk Formation but with important differences as to the definition of its lower and upper boundaries.

Parent

Not definable in new terminology; forms part of the Lower Chalk of the traditional scheme.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to *Acanthoceras rhotomagens*e zones.

References

Jukes-Browne and Hill (1903), for its usage by the Geological Survey, but the term had been in existence for some considerable time prior to that publication in both Survey publications and in journals.

A3.4 CHILTON STONE

Name

First used by Jukes-Browne (1889) to denote a bed that was equated to the Totternhoe Stone of the Chilterns.

Type section

Railway cutting east of Chilton, Oxfordshire.

Primary reference section

As above

Formal subdivision

None

Lithology

Brownish grey limestone. Rough to the touch ('gritty') with many phosphatic nodules.

Definition of upper boundary

Commonly indistinct conformable boundary within the Zig Zag Chalk Formation (Lower Chalk, Grey Chalk unit). Upward reversion to softer, finer grained more typical chalk or marly chalk. May be difficult to locate, even in sections.

Definition of lower boundary

Commonly indistinct conformable boundary with the underlying West Melbury Marly Chalk Formation (Lower Chalk, Chalk Marl unit) but there may be an erosion surface with a concentration of phosphatic pebbles in its base. May be difficult to locate, even in sections.

Thickness

Some 0.6 m at its type site in the cutting east of Chilton on the Didcot to Newbury railway line.

Distribution

Limited to a small area of Berkshire.

Previous names

Equivalent to the Totternhoe Stone of the Chilterns and regarded as the most south-westerly outcrop of that unit.

Parent

Zig Zag Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Acanthoceras rhotomagense* Zone.

References

Jukes-Browne, 1889; Jukes-Browne and Hill, 1889.

A3.5 LOWER CHALK

Name

The term is used for the lowest part of the traditional tripartite scheme of the Chalk (Jukes-Browne and Hill, 1903) and as used is equivalent to a formation.

Type section

In the Chiltern Hills. It was this area utilised to define the Lower Chalk in much of the early literature (Hill and Jukes-Browne, 1886; Jukes-Browne and Hill, 1903).

Primary reference section

Compton Bay, Isle of White
Beachy Head to Eastbourne in Sussex
Folkestone towards Dover in Kent.

Formal subdivision

Divided into the Glauconitic Marl, Chalk Marl, Totternhoe Stone (where present), Grey Chalk, 'White Bed' and Plenus Marls in the traditional scheme.

Lithology

A grey marly chalk with marl content decreasing upwards. No flint. Comprises a thin basal bed of glauconitic marl (Glauconitic Marl, Melbury Sandstone or Cambridge Greensand) overlain by more typical Lower Chalk sequence that is usually divided into a lower 'Chalk Marl'(see West Melbury Marly Chalk Formation entry) with rhythmic alternations of chalk and marl, and an upper 'Grey Chalk' (see Zig Zag Chalk Formation entry) separated by a distinctive hard band (Cast Bed or Totternhoe Stone). (See entries for Grey Chalk and White Chalk Subgroups).

Definition of upper boundary

Conformable at the top of the highest marl within the Plenus Marls Member. (Refer to entries for Zig Zag Chalk and Holywell Nodular Chalk Formations).

Definition of lower boundary

At an unconformity at the base of the Glauconitic Marl, Melbury Sandstone or Cambridge Greensand 'members' at the base of the West Melbury Marly Chalk Member (see reference to the Grey Chalk Subgroup and West Melbury Marly Chalk Formation).

Thickness

Between 45 and 100 m in the Southern and Transitional provinces. Thinner sequences known towards the margins of the Chalk basin and over synsedimentary highs.

Distribution

Throughout the Southern and Transitional provinces and prior to Wood and Smith (1978) used in the Northern Province.

Previous names

Lower Chalk, formerly applied throughout the Chalk outcrop in England but now only used to describe those chalks within the Southern and Transitional provinces beneath the Melbourn Rock in the traditional scheme. Has constituent parts of the Glauconitic Marl, Chalk Marl, Totternhoe Stone (where present), Grey Chalk, 'White Bed' and Plenus Marls. Its use is not recommended for descriptive purposes and should be replaced by the term Grey Chalk Subgroup (but see definition) or the constituent formations within the new scheme.

Lower Chalk (Grey Chalk).

Lower Chalk Formation as used in Bristow, Mortimore and Wood (1997) in an early version of the new Chalk stratigraphy, is the direct equivalent of the Lower Chalk of the traditional scheme.

Lower Chalk without flints as used on the Selby Sheet (71) and Chalk without flint as on the York Sheet (63). (Revision of these sheets will follow the Northern Province terminology). This term is also prevalent in the 19th century literature where it can include the lower flint-free part of the traditional Middle Chalk depending on the author and the area within which the chalks are described.

Lower Beds (Chalk Marl, h5a1) and Upper Beds (h5a2) as utilised on the Cambridge Sheet (188) to denote those beds below and above the Totternhoe Stone.

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to *Metoicoceras geslinianum* zones.

References

Penning and Jukes-Browne, 1881; Rawson et al., 1978.

A3.6 LOWER CHALK FORMATION

Name

This term was erected by Bristow, Mortimore and Wood (1997) to cover the interval of their West Melbury Marly Chalk Member and Zig Zag Chalk Member in recognition of the widespread use of the Lower Chalk in the traditional scheme. Its use is not recommended and is now redundant.

Type section

At the type sections of its constituent members.

Primary reference section

Compton Bay, Isle of White
Beachy Head to Eastbourne in Sussex
Folkestone towards Dover in Kent.

Formal subdivision

Divided into the West Melbury Marly Chalk Member and the Zig Zag Chalk Member.

Age and biostratigraphy

Upper Cretaceous, Cenomanian. *Mantelliceras mantelli* to *Metoicoceras geslinianum* zones.

Lithology

A grey marly chalk with marl content decreasing upwards. No flint. Comprises a thin basal bed of glauconitic marl (Glauconitic Marl, Melbury Sandstone or Cambridge Greensand) overlain by a more typical Lower Chalk sequence that is usually divided into a lower 'Chalk Marl' (see West Melbury Marly Chalk Formation entry) with rhythmic alternations of chalk and marl, and an upper 'Grey Chalk' (see Zig Zag Chalk Formation entry) separated by a distinctive hard band. (Cast Bed or Totternhoe Stone). (See entries for Grey Chalk and White Chalk subgroups).

Definition of upper boundary

Conformable at the top of the highest marl within the Plenus Marls Member. (Refer to entries for Grey Chalk Subgroup, White Chalk Subgroup, Zig Zag Chalk and Holywell Nodular Chalk Formations).

Definition of lower boundary

At an unconformity at the base of Glauconitic Marl, Melbury Sandstone or Cambridge Greensand 'members' at the base of the West Melbury Marly Chalk Member (see reference to Grey Chalk Subgroup and West Melbury Marly Chalk Formation).

Thickness

From 45 to 100 m in the Southern and Transitional provinces. Thinner sequences known towards the margins of the Chalk basin and over synsedimentary highs.

Distribution

Throughout the Southern and Transitional provinces.

Previous names

Lower Chalk of the traditional scheme.

Chalk without flints used on the York Sheet (63) and Lower Chalk (without flints) used on the Selby Sheet (71). Sheet due for revision when the newer Yorkshire/Lincolnshire terminology will be applied (Hunstanton and Ferriby Chalk formations). This term is also prevalent in the 19th century literature where it can include the lower flint-free part of the traditional Middle Chalk depending on the author and the area within which the chalks are described.

Lower Chalk (Grey Chalk).

Parent

Chalk Group

Age and biostratigraphy

Upper Cretaceous Cenomanian. *Mantelliceras mantelli to Metoicoceras geslinianum* zones

References

Bristow, Mortimore and Wood, 1997; Rawson et al., 1978.

A3.7 MIDDLE CHALK

Name

The term is used for the middle part of the traditional tripartite scheme of the Chalk (Jukes-Browne and Hill, 1903) and as used is equivalent to a formation.

Type section

Chiltern area used to define the Lower Chalk in much of the early literature (Hill and Jukes-Browne, 1886).

Primary reference section

Compton Bay, Isle of White; Beachy Head to Eastbourne in Sussex; and Folkestone towards Dover in Kent.

Formal subdivisions

Included the Melbourn Rock as its basal unit.

Lithology

White pure chalk with some flint seams and very shelly beds. Comprises from its base: hard indurated chalk with flaser marls (Melbourn Rock) to exceptionally shelly chalk with flints into chalk with well defined marl seams.

Definition of upper boundary

Bedding plane beneath the Chalk Rock in the Chilterns (Transitional Province) and beneath the equivalent beds containing the '*reussianum* fauna' elsewhere in the Southern Province.

Definition of lower boundary

Conformable at the base of Melbourn Rock above highest marl within Plenus Marls.

Thickness

Between 75 and 95 m in the Southern and Transitional provinces. Thinner sequences are known towards the margins of the Chalk basin and over synsedimentary highs.

Distribution

Throughout the Southern and Transitional provinces.

Previous names

Chalk with few flints.

Chalk with flints (Middle Chalk) on the York Sheet (63) and Middle Chalk with flint on the Selby Sheet (71). Sheets due for revision when the newer Yorkshire/Lincolnshire terminology will be applied (Hunstanton and Ferriby Chalk formations). This term is also prevalent in the 19th century literature where it can include the lower flint-free part of the traditional Middle Chalk depending on the author and the area within which the chalks are described.

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous Cenomanian and Turonian. *Neocardioceras juddii* to *Terebratulina lata* zones.

Reference

Penning and Jukes-Browne, 1881.

A3.8 MIDDLE CHALK FORMATION

Name

This term was erected by Bristow, Mortimore and Wood (1997) to cover the interval of their Holywell Nodular Chalk Member and New Pit Chalk Member in recognition of the widespread use of the Middle Chalk in the traditional scheme. Its use is not recommended and is now redundant.

Type section

At the type sections of its constituent members.

Primary reference section

Compton Bay, Isle of White; Beachy Head to Eastbourne in Sussex; and Folkestone towards Dover in Kent.

Formal subdivision

Includes the Melbourn Rock as its basal unit.

Lithology

White pure chalk with some flint seams and very shelly beds. Comprises from base: hard indurated chalk with

flaser marls (Melbourn Rock) to exceptionally shelly chalk with flints into chalk with well defined marl seams. The Holywell Nodular Chalk Member and New Pit Chalk Member are its constituent parts.

Definition of upper boundary

Coincident with the base of the Lewes Nodular Chalk Member. Conformable at the incoming of nodular chalk and regular flint seams.

Definition of lower boundary

Conformable at the base of the Melbourn Rock.

Thickness

From 75 to 95 m in the Southern and Transitional provinces. Thinner sequences known towards the margins of the Chalk basin and over synsedimentary highs.

Distribution

Throughout the Southern and Transitional provinces.

Previous names

Middle Chalk of the traditional scheme. Chalk with few flints. Chalk with flints (Middle Chalk) on the York Sheet 63 and Middle Chalk with flints on the Selby Sheet 71. Sheets due for revision when the newer Yorkshire/ Lincolnshire terminology will be applied. This term is also prevalent in the 19th century literature.

Parent

Chalk Group

Age and biostratigraphy

Upper Cretaceous Cenomanian and Turonian. *Neocardioceras juddii* to *Terebratulina lata* zones.

References

Bristow, Mortimore and Wood, 1997; Rawson et al., 1978.

A3.9 RED CHALK

Name

The term Red Chalk is of great antiquity being used since the middle of the 19th century. It has been used generally subsequently often including Hunstanton in its title. Now redefined as the Hunstanton Formation.

Type section

Hunstanton Cliff [TF 6725 4130 to TF 6786 4238], north Norfolk (Owen, 1995; Gallois, 1994).

Primary reference section

South Ferriby Quarry [SE 9915 2045], Lincolnshire (Gaunt et al., 1992).

Formal subdivision

None

Lithology

Rubbly to massive chalks with marl bands; typically pink to brick-red in colour (due to disseminated hematite), but locally upper part grey due to secondary alteration of the iron minerals. Commonly sandy, particularly in lower part.

Definition of upper boundary

Erosion surface, locally developed as a hardground, overlain by nodular chalk (lowest Cenomanian) of Paradoxica (or Sponge) Bed or (in Cleveland Basin) Crowe's Shoot Member (Mitchell, 1995); this horizon (the base of the Lower Chalk in Norfolk, or elsewhere of the Ferriby Formation) may or may not correspond with the upper limit of red chalks.

Definition of lower boundary

Sharp or [apparently] gradational boundary of marly chalks with ferruginous sandstones of Carstone Formation in the Transitional Province, Lincolnshire and Yorkshire or (in Cleveland Basin) with mudstone of Speeton Clay Formation; commonly marked by a line of phosphatic nodules (burrow-fills).

Thickness

About 1 m at type section in Norfolk, typically 3 m in Lincolnshire and south Yorkshire, thinning over Market Weighton High but expanding up to about 30 m in Cleveland Basin with about 24 m in cliffs at Speeton.

Distribution

North Norfolk, Lincolnshire and Yorkshire in the Northern Province.

Previous names

Red Chalk; Red Chalk Member as part of the Ferriby Formation as per Wood and Smith (1978); Red Chalk (Hunstanton Member) as above. Hunstanton Limestone; Hunstanton Red Rock; Hunstanton Chalk Formation; Hunstanton Red Chalk Formation (Owen, 1995); Hunstanton Chalk Member (Wood and Smith, 1978).

Parent

Not definable in the new terminology, as the Hunstanton Formation it is a stand-alone unit excluded from the Chalk Group. Part of the Ferriby Chalk Formation of Wood and Smith (1978).

Age and biostratigraphy

Lower Cretaceous, Albian.

References

Owen (1995), as modified herein (see entry for Hunstanton Chalk Formation).

A3.10 UINTACRINUS BAND

Name

A term used on the Faversham and Ramsgate geological sheets to denote a mappable boundary within the Upper Chalk.

Type section

Graves in St Peters churchyard [TR 3779 6862].

Primary reference section

Top of Cliff at Foreness Point (see Rasmussen, 1961).

Formal subdivision

None

Lithology

Soft white chalk with some flints.

Definition of upper boundary

At the incoming of the *Offaster pilula* index fossil.

Definition of lower boundary

At the incoming of the zonal index fossil.

Thickness

From 2 to 3 m at the top of the Zone of *Marsupites testudinarius* as originally defined in Kent.

Distribution

Confined to the Faversham and Ramsgate geological sheets.

Previous names

None

Parent

Newhaven Chalk Formation.

Age and biostratigraphy

Upper Cretaceous, Campanian. *Uintacrinus anglicus* Zone.

Reference

Shephard-Thorn, 1988.

A3.11 UPPER CHALK

Name

The term is used for the highest part of the traditional tripartite scheme of the Chalk (Jukes-Browne and Hill, 1903) and as used is equivalent to a formation.

Type section

Type areas of East Kent Cliffs, Sussex Cliffs, Isle of Wight and Dorset cliffs.

Primary reference section

See above

Formal subdivision

Includes the Chalk Rock as its basal unit.

Lithology

Generally soft white chalk with flints and marl seams throughout. Variation in the relative proportions of marl and flint seams indicative of major constituent units. Hard nodular chalks at base.

Definition of upper boundary

Unconformable and limited by the pre-Palaeogene erosion surface.

Definition of lower boundary

Conformable and placed at the base of the Chalk Rock in the Transitional Province and at the lowest nodular chalk containing the *Hyphantoceras reussianum* fauna in the Southern Province, or at the base of the 'Basal Complex' in East Kent. When used in the Northern Province the boundary is at a horizon marking the base of the *Sternotaxis plana (now Plesiocorys plana)* Zone.

Thickness

Variable depending on degree of post-Cretaceous erosion and the relative development of its constituent formations. Onshore the thickest development is within the Hampshire/Sussex area of the Southern Province, where up to about 470 to 515 m of strata are preserved; the most chronostratigraphically complete succession is in Norfolk but is thought there to be only some 350 m thick; within the Northern Province up to 500 m are preserved but the thickest succession is within the North Sea area where about 800 to 1100 m are preserved.

Distribution

Throughout the Southern and Transitional provinces.

Previous names

Upper Chalk with flint of BGS usage and is also prevalent in the 19th century literature.

Substantially equivalent to the Upper Chalk Formation of Bristow, Mortimore and Wood (1997), and the White Chalk Subgroup of Rawson, Allen and Gale (2001).

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Turonian to Maastrichtian. *Sternotaxis plana (now Plesiocorys plana)* Zone to highest belemnite zones preserved.

Reference

Jukes-Browne and Hill, 1903, 1904.

A3.12 UPPER CHALK FORMATION

Name

This term was erected by Bristow, Mortimore and Wood (1997) to cover the interval of their Lewes Nodular Chalk Member to the Portsdown Chalk Member in recognition of the widespread use of the Upper Chalk in the traditional scheme. It use is not recommended and is now redundant.

Type section

At the type sections of its constituent members.

Primary reference section

Compton Bay, Isle of White; Beachy Head to Eastbourne in Sussex and Folkestone towards Dover in Kent.

Formal subdivision

Includes the Lewes Nodular Chalk Member, Seaford Chalk Member, Newhaven Chalk Member, Tarrant Chalk Member, Spetisbury Chalk Member and Portsdown Chalk Member.

Lithology

Generally soft white chalk with flints and marl seams throughout. Variation in the relative proportions of marl and flint seams indicative of major constituent units. Hard nodular chalks at base.

Definition of upper boundary

Unconformable and limited by the pre-Palaeogene erosion surface.

Definition of lower boundary

Conformable, coincident with the base of the Lewes Nodular Chalk Member (of Bristow, Mortimore and Wood, 1997) and the Lewes Nodular Chalk Formation (of Rawson, Allen and Gale, 2001). It is placed at the incoming of hard nodular chalks and regular well-developed flint seams. This horizon is known to be diachronous in the Southern and Transitional provinces.

Thickness

Variable depending on degree of post-Cretaceous erosion and the relative development of its constituent formations. Onshore the thickest development is within the Hampshire/Sussex area of the Southern Province, where up to about 470 to 515 m of strata are preserved; the most chronostratigraphically complete succession is in Norfolk but is thought there to be only some 350 m thick; within the Northern Province up to 500 m are preserved but the thickest succession is within the North Sea area where about 800 to 1100 m are preserved.

Distribution

Throughout the Southern and Transitional provinces.

Previous names

Upper Chalk. Upper Chalk with flints.

Parent

Chalk Group.

Age and biostratigraphy

Upper Cretaceous, Turonian to Maastrichtian. *Terebratulina lata* Zone to highest belemnite zones preserved.

References

Bristow, Mortimore and Wood, 1997; Rawson et al., 1978.

The following is a list of terms appearing in the major lithostratigraphical papers. They are terms that are infrequently utilised in BGS descriptive texts. An attempt has been made to give the relevant parent unit or approximate correlative term within the New Chalk Stratigraphy. For the most part these terms can be considered as being at member or bed level.

A3.13 Mortimore (1986)

This paper essentially deals with the beds attributable to the Middle and Upper Chalk of the Traditional Scheme for which he adopted the term the Sussex White Chalk Formation and which he further divided into six members. The units so described are designated from his study of the thicker 'basinal' chalk successions exposed on the coast and in large inland sites in the South Downs, the Hampshire/Wiltshire 'Downs' and the Isle of Wight. The Lower Chalk of the area was not considered in this paper. The essential elements of this study formed the basis for the mapping scheme whose development resulted in the presently accepted unified scheme (Rawson, Allen and Gale, 2001). It follows that many of the terms described below (i.e. formation, member and bed) would be considered at the next higher level in the unified scheme. Numerous marker flint, marl, hardground and other units at bed level are given codes in the BGS Lexicon for use in borehole coding. They are not defined further in the lexicon and reference should always be made to Mortimore (1986) for their understanding.

Sussex White Chalk Formation

Base is at the junction of the Melbourn Rock and the underlying Plenus Marls as traditionally defined, with the top of the formation limited beneath the sub-Palaeogene erosion surface. Essentially equivalent to the White Chalk Subgroup with the proviso that the Plenus Marls are excluded from the Sussex White Chalk Formation.

Ranscombe Chalk Member

The basal member of the Sussex White Chalk Formation whose lower boundary is coincident with the base of the Melbourn Rock. This unit covers the majority of the Middle Chalk of the traditional scheme and is equivalent to the Holywell Nodular Chalk Formation (excluding the Plenus Marls Member) and the New Pit Chalk Formation. Overlain by the Lewes Nodular and Flinty Chalk Member.

Melbourn Rock The basal unit of the Ranscombe Chalk Member and the Sussex White Chalk Formation. As defined is most closely equivalent to the traditional understanding of the Melbourn Rock of the Chilterns and Thames valley. Base placed at the Foyle Marl.

Holywell Beds As originally defined the beds are divided into Lower, Middle and Upper units whose bases are placed respectively at the Meads Marl 1, Gun Gardens Marl 1 and the Gun Gardens Main Marl. This was modified (Mortimore and Pomerol, 1996) with the Upper unit considered to be equivalent to the lowest part of the New Pit Chalk Member as defined in BGS mapping. With the Melbourn Rock, the Lower and Middle Holywell Beds are equivalent to the Holywell Chalk Member of Bristow, Mortimore and Wood (1997) and with the further addition of the Plenus Marls Member equivalent to the Holywell Nodular Chalk Formation of Rawson, Allen and Gale (2001).

New Pit Beds As originally defined the beds covered the interval from the Malling Street Marls to the Glynde Marl 1. This was modified (Mortimore and Pomerol, 1996) with the upper unit of the Holywell Beds considered to be equivalent to the lowest part of the New Pit Chalk Member, and the top of the Member being taken at the incoming of nodular chalks, as defined in BGS mapping (Bristow, Mortimore and Wood, 1997), which is invariably in the Glynde Marl 4 to Southerham Marl 1 interval. The New Pit Chalk Member so defined is the direct equivalent of the New Pit Chalk Formation of Rawson, Allen and Gale (2001).

Lewes Nodular and Flinty Chalk Member

As originally defined the member covered the interval between the Glynde Marl 1 and the uppermost of the Shoreham Marls including most of the nodular flinty chalks of Turonian and Coniacian age. The member includes an informal Lower and Upper part. This was modified in Mortimore and Pomerol (1996) with the Lower Lewes Nodular Chalk defined as the succession from the inception of nodularity (immediately above the Glynde Marl 4 in Sussex) to the Lewes Marl; and (presumably) the Upper Lewes Nodular Chalk from the Lewes Marl to the Shoreham Marl 2. In total this member has the same definition as the Lewes Nodular Chalk Member of Bristow, Mortimore and Wood (1997) and accords with the definition of the Lewes Nodular Chalk Formation of Rawson, Allen and Gale (2001) as applied to the basinal successions of the Southern Province. The inception of nodularity becomes younger northwards into the Transitional Province i.e. the base of the formation is diachronous up to approximately the level of the Ringmer/Kingston Beds.

Glynde Beds Basal marker is Glynde Marl 1. This interval contains the boundary between the New Pit Chalk and Lewes Nodular Chalk Formations of Rawson, Allen and Gale (2001) as defined in the Southern Province.

Caburn Beds Basal marker — Southerham Marl 1.

Ringmer Beds Basal marker — the Caburn Marl. In the Transitional Province the Caburn Marl is the lateral

equivalent of the Reed Marl, which is beneath the inception of nodularity (the Chalk Rock Member) in the Reed Quarry. Known as the Bridgewick Beds (Mortimore, 1983).
Kingston Beds Basal marker — the Bridgewick Marl 1, includes the distinctive fauna of the Chalk Rock Member.
South Street Beds Basal marker — Lewes Marl. Known as Lewes Beds (Mortimore, 1983).
Navigation Beds Basal marker — Snowdrop Flint 1.
Cliffe Beds Basal marker — the upper Navigation Marl.
Hope Gap Beds Basal marker — the top surface of the Cliffe Hardground.
Beeding Beds Basal marker — the top surface of the Hope Gap Hardground.
Light Point Beds Basal marker — the top surface of the Beeding Hardground.
Beachy Head Beds Basal marker — the top surface of the uppermost Light Point Hardground.

Seaford Chalk Member

As originally defined the member covered the interval between the Shoreham Marl 2 and the Buckle Marl 1. This is equivalent to the member concept in Bristow, Mortimore and Wood (1997) and the Seaford Chalk Formation of Rawson, Allen and Gale (2001).
Belle Tout Beds Basal marker — the Shoreham Marl 2
Cuckmere Beds Basal marker — the Seven Sisters Flint.
Haven Brow Beds Basal marker — the Michel Dean Flint. Known as Seaford Head Beds (Mortimore, 1983).

Newhaven Chalk Member

As originally defined the member covered the interval between the Buckle Marl 1 and the Castle Hill Marl 2. This is equivalent to the member concept of Bristow, Mortimore and Wood (1997) with the proviso that in full successions in structural lows additional marls are strongly developed (the Pepper Box Marls) above the Castle Hill Marls. This higher level marks the mapping boundary in this situation.
Splash Point Beds Basal marker — the Buckle Marl 1.
Old Nore Beds Basal marker — the Brighton Marl.
Peacehaven Beds Basal marker — the Old Nore Marl.
Meeching Beds Basal marker — the Peacehaven Marl.
Bastion Steps Beds Basal marker — the Meeching Paired Marl.

Culver Chalk Member

As originally defined the member covered the interval between the Castle Hill Marl 2 and the Portsdown Marl. This is equivalent to the member concept of Bristow, Mortimore and Wood (1997) with the proviso that the mapping base may be slightly lower at the Arundel Sponge Beds or slightly higher at the Pepper Box Marls. It conforms to the definition of the Culver Chalk Formation of Rawson, Allen and Gale (2001).
Castle Hill Beds Basal marker — the Castle Hill Marl 2.
Sompting Beds Basal marker — the Lancing Flint.
Whitecliff Beds Basal marker — the Whitecliff Marl.

Portsdown Chalk Member

As originally defined the member covered the interval from the Portsdown Marl up to the sub-Palaeogene unconformity in the Southern Province. This upper level is some distance (about 8 m) above the Shide Marl as exposed at Whitecliffe Bay on the Isle of White (as in Mortimore, 1986) but younger chalks are known at this locality (Mortimore, Wood and Gallois, 2001) and elsewhere on the Isle of Wight and in Dorset. Gale, Wood and Bromley (1987) introduced the term Studland Chalk of 'member' status to define the marl-free soft white chalk with large flints in the upper part of the chalk exposed in Scratchells Bay and Alum Bay and on the Dorset coast in Studland Bay. It is not discernible from the published literature at what level the division of the Portsdown and Studland 'members' of Gale, Wood and Bromley (1987) occurs in the highest preserved chalk sequence. This doubt together with the lack of exposure and geomorphological expression of the member has led to the BGS reverting to the original concept of the Portsdown Chalk Member (Bristow, Mortimore and Wood, 1997). This is also the position stated in Rawson, Allen and Gale (2001) and thus the Portsdown Chalk Formation covers all of the chalk up to the sub-Palaeogene erosion surface in the Southern Province.

Redoubt Beds Basal marker — the Portsdown Marl

A3.14 Robinson (1986)

This paper describes and erects a lithostratigraphical terminology for the chalk of the North Downs. The paper reclassifies the Lower, Middle and Upper Chalk of the Traditional Scheme on the basis of distinct types of chalk and associations. The succession is divided completely into five formations and nine members with a large part of the lowest formation being undivided at member level. It is not easy to correlate the divisions of Robinson to biostratigraphical terminology without significant knowledge of the literature, however the succession is essentially the same and can be described using the terms as defined in Sussex by Mortimore (1986). Thus the work is largely redundant in terms of the new agreed lithostratigraphical framework.

East Wear Bay Chalk Formation

Defined on the coastal section between Copt Point [TR 242 365], near Folkestone, and Hay Cliff [TR 301 394] where it is approximately 58 m thick. Its base is at the erosional contact beneath the Glauconitic Marl Member and its top is defined as the base of the overlying Hay Cliff Member of the Abbots Cliff Formation and placed at the 'omission surface beneath the lowest layer containing laminated structures'. The formation is undivided above the Glauconitic Marl Member. The formation is essentially equivalent to all of the Lower Chalk of the Traditional Scheme beneath the Jukes-Browne Bed 7. The 'Cast Bed' is present in the succession (but not used to divide the sequence) and demonstrates that the formation is equivalent to all of the West Melbury Marly Chalk Formation and the lower half if the Zig Zag Chalk Formation. Equivalent to the *Mantelliceras mantelli* Zone to the very basal *Acanthoceras jukesbrownei* Zone.

Glauconitic Marl Member

This is the basal member of the East Wear Bay Chalk Formation and is defined at Copt Point where it is about 5 m thick. Its top is placed above a nodular bed equated to be that of Bed 'h' in Band 1 of Kennedy (1969). Equivalent to the *Neostlingoceras carcitanense* Subzone.

Abbots Cliff Chalk Formation

The formation (and its constituent members) is named from (and its stratotype is at) the Abbots Cliff path [TR 268 385] where it is 22 m thick. The formation is divided into two members, the lower, Hay Cliff Member being overlain by the Capel-le-Ferne Member. The base is defined at the 'omission surface beneath the lowest layer containing

laminated structures' and its top coincident with the base of the Plenus Marl Formation. It is equivalent to the Jukes-Browne Bed 7 and 'White Bed' (JB Bed 8) of the Traditional Scheme and to the upper half of the Zig Zag Chalk Formation. Equivalent to the *Acanthoceras jukesbrownei* Zone and *Calycoceras guerangeri* Zone.

Hay Cliff Member

Indurated calcarenite equivalent to the Jukes-Browne Bed 7 of the Traditional Scheme, basal *Acanthoceras jukesbrownei* Zone. The base is defined at the 'omission surface beneath the lowest layer containing laminated structures'.

Capel-le-Ferne Member

Bioturbated soft white Chalk equivalent to the 'White Bed' (JB Bed 8) of the Traditional Scheme and the Falling Sands 'Member' of Mortimore, Pomerol and Foord (1990) (or 'Beds' of Bristow, Mortimore and Wood, 1997). Topmost *Acanthoceras jukesbrownei* Zone and *Calycoceras guerangeri* Zone. The top defined as being coincident with the base of the Plenus Marl Formation at the sub-plenus erosion surface of Hill and Jukes-Browne (1886).

Plenus Marl Formation

This unit is directly equated to the *Actinocamex plenus* (now *Praeactinocamax plenus*) Subzone of Jefferies (1963) defined at Merstham [TQ 295 542] with the proposal that Shakespeare Cliff [TR 307 398] be designated its primary reference section. Here it is 2.67 m thick. Base marked by the sub-plenus erosion surface with a top above the highest of the Plenus Marl 'Beds' of Jefferies (1963), the Foyle Marl of Mortimore (1986). It is equivalent to the Plenus Marls (Jukes-Browne Bed 9) of the Traditional Scheme and the Plenus Marls Member of the Holywell Nodular Chalk Formation in the new scheme. Equivalent to most of the *Metoicoceras geslinianum* Zone.

Dover Chalk Formation

This formation is divided into three constituent parts; the Shakespeare Cliff, Aycliffe and Akers Steps members, each containing and limited by named marker beds, with the stratotype designated as Akers Steps [TR 297 394] where 66.9 m of beds are present. The base is taken at the base of the Melbourn Rock Beds and the top placed at the Crab Bay Marl. The formation is equivalent to the Bed 4 and Bed 5 units defined by Whitaker, Bristow and Hughes (1872) and most of the Middle Chalk of the Traditional Scheme. It is equivalent to the Holywell Nodular Chalk Member (but not the newly defined formation of that name which includes the Plenus Marls Member), New Pit Chalk Formation and the lower part of the Lewes Nodular Chalk Formation. As defined the formation covers the *Neocardioceras juddii* to *Terebratulina lata* Zones.

Shakespeare Cliff Member

The Melbourn Rock Beds (about 12 m) form the lowest part of the Shakespeare Cliffe Member, which terminates upwards at the Warren Marl 1. The member being 26.5 m thick at its stratotype. The member is typically composed of beds of nodular and intraclastic chalk with spectacular concentrations of shell-detrital chalks containing *Mytiloides* within which the Round Down Marl is the only named marker. This member is equivalent to the 'Grit Beds' in the early literature and the Holywell Nodular Chalk Member of Bristow, Mortimore and Wood (1997).

Aycliff Member

This member is 17.5 m thick at its stratotype and comprises essentially flintless white chalk with marl seam and weakly nodular chalk. The lower boundary is placed at the Warren Marl 1, which is the lateral equivalent of the New Pit Marl 1 in the Sussex succession, and the top is placed, rather unsatisfactorily, at the base of the first persistent flint up-sequence from the Maxton Marls. These marls being the lateral equivalent of the Glynde Marls in Sussex. Thus the member is essentially the equivalent of the New Pit Chalk Formation, as defined in Sussex, with the proviso that nodular chalks, characteristic of the Lewes Nodular Chalk Formation, are not encountered in Kent until only a few metres below the Langdon Bay Marls (the Southerham Marls of Sussex) higher still in the succession. The member is entirely within the *Terebratulina lata* Zone.

Akers Steps Member

This unit is 17.5 m thick at its stratotype at Akers Steps and includes the inception of nodularity as seen in the North Downs successions. The first nodular beds appear approximately 5 m below the Langdon Bay Marls, which are equivalent to the Southerham Marls in the Sussex succession, but the base of the member is placed lower (about 15 m lower) at the first persistent flint below the Lydden Spout Flint. The top of the member is defined as the basal surface of the Crab Bay Marl that is the lateral equivalent of the Caburn Marl in the Sussex sequence. As the inception of nodularity indicates the base of the Lewes Nodular Chalk Formation in mapping terms, the lower part (about 10 m) of this member is to be considered as part of the New Pit Chalk Formation (but is the lateral equivalent of the Glynde Beds of the Sussex chalk). The upper part of the member is equivalent to the Caburn Beds of the Sussex Chalk. The member is entirely within the *Terebratulina lata* Zone.

Ramsgate Chalk Formation

This formation is divided into three constituent parts, the St Margarets, Broadstairs and Margate members each containing and limited by named marker beds. The stratotype is composite from the Dover to Thanet coast of Kent (see member entries) where about 120 m of beds are seen. The base is taken at the base of the Crab Bay Marl with the top limited by the sub-Palaeogene erosion surface. The formation is equivalent to the Bed 3, Bed 2 (Broadstairs Chalk) and Bed 1 (Margate Chalk) units defined by Whitaker, Bristow and Hughes (1872). The formation covers the highest beds of the Middle Chalk and all of the known Upper Chalk (in the North Downs) of the Traditional Scheme. It is equivalent to the middle and upper part of the Lewes Nodular Chalk Formation, the Seaford Chalk Formation and the lower part of the Newhaven Chalk Formation. As defined the formation covers the *Terebratulina lata* to *Offaster pilula* zones.

St Margarets Member

This member is defined at the Langdon Stairs [TR 345 425] stratotype where 38.3 m of beds are encountered. The base is at the Crab Bay Marl (Caburn Marl) and its top placed at the East Cliff Marl 2 (Shoreham Marl 2). The member comprises nodular chalks with mineralised hardgrounds and regular strong nodular flint seams. It is equivalent to the 'middle' and 'upper' Lewes Nodular Chalk Formation.

Broadstairs Member

Defined at four sites representing a composite stratotype at St Margarets Bay [TR 371 446], Kingsdown Rifle Range [TR 380 473], Pegwell Bay [TR 368 640] and Joss Bay [TR 398 702] where it has a combined thickness of 58.5 m. The base is placed at the East Cliff Marl 2 (Shoreham Marl 2) and its top at the upper surface of the Barrois Sponge Bed. As defined it is the direct equivalent of the Seaford Chalk Formation.

Margate Member

The member is defined at two sites which constitute the composite stratotype at White Ness [TR 396 710] and Foreness Point [TR 384 716] on the Isle of Thanet in Kent where 22.5 m are preserved beneath the sub-Palaeogene erosion surface. The base is at the Barrois Sponge Bed. The member comprises soft white, marl-free, flint-poor chalk. Because of its lithological differences the Margate Member is retained in the new lithostratigraphical scheme within the Newhaven Chalk Formation that is thicker and stratigraphically more extensive (with significant marls) elsewhere.

A3.15 Jarvis and Woodroof (1984)/Jarvis and Tocher (1987)

The succession of Upper Cretaceous sediments in south-east Devon is lithologically distinct principally because of its presumed proximity to the basin margin and synsedimentary structural control. The succession is divided into two formations and six members with numerous named marker beds. In the 1984 paper the highest beds described are from the Beer Roads Flinty Chalk Member up to 'Rowe's Two Foot Band' (Common Hill Marl, locally; or New Pit Marl 1 in the main basin). In the later (1987) paper the the higher part of the Beer Roads Flinty Chalk member and beds equated to the St Margarets and Broadstairs members of the North Downs (Robinson, 1986, see above) succession are described. The whole succession is however better understood by comparison to the Sussex sequence (see Mortimore, 1986; Mortimore, Wood and Gallois, 2001).

Beer Head Limestone Formation

The formation is divided into four members (but each not present everywhere) each defined by lithostratigraphical markers determined from stratotype sections between Branscombe [SY 204 882] and Seaton/White Cliff [SY 233 893] in Devon. Because of the marked lithological differences, condensation and omission in this marginal setting the term is utilised instead of the West Melbury Marly Chalk and Zig Zag formations in BGS descriptive texts with the proviso that the highest, Pinnacles Member is demonstrably equivalent to the Plenus Marls Member and Melbourn Rock Member and therefore excluded from the Beer Head Limestone Formation. Thus the BGS usage accords with the Cenomanian Limestone as adjusted in Smith (1965) and Beds A1, A2 and B of Jukes-Browne and Hill (1903). It is equivalent to the Zig Zag and West Melbury Marly Chalk formations or the Grey Chalk Subgroup.

Pounds Pool Sandy Limestone Member

The 'stratotype' for this member is at Pounds Pool Beach [SY 227 881] where it is 3.5 m thick. Its base is placed on the surface of the Small Cove Hardground of the Upper Greensand Formation with its top on the upper surface of the Weston Hardground. The member comprises yellowish brown very coarse calcareous sandstone passing up into indurated sandy bioclastic limestone. Biostratigraphically the member is reported to be in the *Neostlingoceras carcitanensis* Subzone, *Mantelliceras mantelli* Zone of the Lower Cenomanian. The member is equivalent to Bed A1 of Jukes-Browne and Hill (1903) and Smith (1965) and the lower part of the West Melbury Marly Chalk Formation.

Hooken Nodular Limestone Member

Named after Hooken Cliffs adjacent to the Beer Stone Adit [SY 219 879] where the member achieves its maximum thickness of 5 m. The base of the member is placed at the upper surface of the Weston Hardground and its top on the upper surface of the King's Hole Hardground. It is composed of grey, shell-detrital rubbly limestone at various stages of induration. Inland the lateral equivalent of this member is termed the **Wilmington Sand** Facies (or member of some authors), which is composed of decalcified sand and sandy calcarenite overlain by highly fossiliferous sand with a chalky matrix ('Grizzle'). Kennedy (1970) regarded this member as being of *Mantelliceras saxbii* Subzone *Mantelliceras mantelli* Zone age. There is a major hiatus between this and the succeeding member. The member is equivalent to Bed A2 of Jukes-Browne and Hill (1903) and Smith (1965) and the upper part of the West Melbury Marly Chalk Formation.

Little Beach Bioclastic Limestone Member

The member is thickest (1.75 m) at the Beer Stone Adit but seen to advantage in fallen blocks on Little Beach. It is a greatly condensed and complex bioclastic limestone sequence commencing with the 'cavernous hardground'. The base is at the King's Hole Hardground surface and its top at the Humble Point Hardground. Records show the member to be of *Turrilites costatus* Subzone (*Acanthoceras rhotomagense* Zone) to *Acanthoceras jukesbrownei* Zone with reworked material from older zones at the base and therefore is of Middle Cenomanian age. There is a major hiatus between this and the succeeding member. The member is equivalent to Bed B of Jukes-Browne and Hill (1903) and Smith (1965) and to much of the Zig Zag Chalk Formation.

Pinnacles Glauconitic Limestone Member

Named after the Pinnacles, which stand proud of the Hooken Cliffs, the member attains a maximum thickness there of 2.3 m. The member is confined between the top surfaces of the Humble Point Hardground and the Haven Cliff Hardground. Biostratigraphically the member contains a reworked fauna representing a part of the Middle and Upper Cenomanian and an indigenous fauna of *Metoicoceras geslinianum* Zone with *Neocardioceras juddii* Zone in the Haven Cliff Hardground. The member is equivalent to Bed C of Jukes-Browne and Hill (1903) and Smith (1965) and the basal Plenus Marls and Melbourn Rock members of the Holywell Nodular Chalk Formation.

Seaton Chalk Formation

The formation is divided into two members each defined by marker beds determined from the White Cliff stratotype between Beer and Seaton [SY 233 886]. The formation is equivalent to the Middle Chalk of the Traditional Scheme and the Holywell Nodular Chalk and New Pit formations of the new scheme.

Connett's Hole Nodular Chalk Member

Defined at White Cliff where 13.5 m of beds are preserved. The base is placed at the surface of the Haven Cliff Hardground and the top at the upper surface of the last nodular bed (the Flinty Hardground 5). The member is characterised by nodular chalk with hardgrounds, glauconitic and sandy at the base, and is poorly flinty above the Branscombe Hardground. The **Beer Stone**, an important architectural freestone, is derived from a particularly pure, grey, fine-grained calcarenite lens in the lower part of the succession. The obvious West Ebb Marl is an important marker in the succession above the Beer Stone. There is a marked non-sequence beneath the Beer Roads Flinty Chalk Member over much of the outcrop that cuts out the highest beds down to the level of the Branscombe Hardground. This hardground itself cuts out the lower part of the succession entirely, to the west, where it sits on the Pinnacles Member. Biostratigraphically it covers the *Mytiloides* spp. Zone and is equivalent to the Holywell Nodular Chalk Formation.

Beer Roads Flinty Chalk Member

Named after the eastern side of Beer Beach [SY 232 892]. The base is at the surface of the Flinty Hardground 5 and the top at the inception of nodularity a metre or so below the Whitlands Marl on the Pinhay Cliffs (see Jarvis and Tocher, 1987). The member is characterised by soft white chalks with numerous flint and marl seams. Flint is less prominent to the east where the succession becomes more like the New Pit Chalk Formation of Sussex. The distinct marker beds known as Rowe's Two Foot and Four Foot bands are equated to the New Pt 1 and 2 marls in Sussex. Biostratigraphically the member is equivalent to the *Terebratulina lata* Zone and thus essentially the New Pit Chalk Formation.

A3.16 Johansen and Surlyk (1990)

This paper dealing principally with the distribution of brachiopods within the upper Campanian and lower Maastrichtian chalk in Norfolk formalises, in lithostratigraphical terms and with some additions, the essentially biostratigraphical work of Peake and Hancock (1970); a paper which also describes the entire chalk succession in the county (see also Brydone, 1908). In this earlier paper these chalks are referred to the 'Zone of *Belemnitella mucronata*', which they equate to the '**Norwich Chalk**' of previous authors. This Norwich Chalk term is again used, informally but presumably implying formation status, by Mortimore, Wood and Gallois (2001), to cover all of the Chalk of Norfolk above the Portsdown Chalk Formation. The Norwich Chalk (and the stratigraphically higher Trimmingham Chalk) is the lateral equivalent of the Rowe Chalk Formation, as defined, of the Northern Province.

The Basal mucronata *Chalk 'Member'*

This is noted as the unit below their formally defined units and the name is taken from Peake and Hancock (1970). Its base is not formally defined but presumed to be at the base of the zonal index belemnite. Peake and Hancock estimate it to be 50 feet (15.2 m) of firm white chalk with frequent flints. Also known as the lower part of the pre-Weybourne Chalk.

Eaton Chalk Member

This overlies the 'Basal *mucronata* chalk' and is the oldest unit formally described. The base is ill defined within the *Belemnitella mucronata* sensu stricto Zone (at the base of the *Echinocorys marginata* approaching *subglobosa* 'zone', Peake and Hancock, 1961,1970). The member is also known as the upper part of the pre-Weybourne Chalk. Peake and Hancock estimate it to be 50 feet (15.2 m) of soft chalks with irregularly scattered flints.

Weybourne Chalk Member

The base of this member is placed at the top of the sponge-bed hardground above Flint Z in the section at Weybourne Hope. Peake and Hancock estimate it to be 75 feet (22.8 m) of chalk with bands of strongly developed flints. It is mostly coincident to the *Belemnitella woodi* Zone of Christensen (1995, 1999).

Catton Sponge Bed

This is the topmost unit of the Weybourne Chalk Member. The base is marked by the incoming of sponges and its top is placed above the hardground. It varies between 0.3 m and a few metres in thickness and comprises one to three yellow stained hardgrounds and soft chalk with flint.

Beeston Chalk Member

The lower boundary placed at the surface above the Catton Sponge Bed whilst the upper boundary is poorly defined at a hardground on the coast at West Runton. The member comprises soft white chalk with irregular seams of large flints. Together with the Catton Sponge Bed below, the beds cover most of the *Belemnitella minor* I Zone of Christensen (1995, 1999). Peake and Hancock estimate it to be 75 feet (22.8 m) thick.

Paramudra Chalk Member

The lower boundary is placed at the hardground described above but the top is ill defined in glacially disturbed masses but conventionally placed at the Overstrand Pyramidata Hardground. The member comprises soft white chalk with large vertical, cylindrical 'Paramudra' flints and repeated hardgrounds. It is equivalent for the most part with the *Belemnitella minor* II Zone of Christensen (1995, 1999). Peake and Hancock estimate it to be 75 feet (22.8 m) thick.

Sidestrand Chalk Member

Lower boundary placed at the Overstrand Pyramidata Hardground with the top at the hardground labelled 'O' in Peake and Hancock (1970, fig 7). The member includes the Sidestrand Chalk and Porosphaera Beds of Peake and Hancock (1970), which they equated with the *Belemnella lanceolata* 'zone', in the lowermost Maastrichtian. The member is between 10 and 12 m of white soft infrequently nodular chalk with regular flint seams. It forms part of the *Belemnella lanceolata, B. psuedobtusa* and *B. obtusa* zones of Christensen (1999).

Trimingham Sponge Beds Member

Lower boundary at the top of the Sidestrand Chalk Member and a top at the marl band (the 'greasy' marl) labelled 'G' in Peake and Hancock (1970, fig 7). Equivalent to the 'Sponge Beds' of Brydone (1908) and Peake and Hancock

(1970). The member is 2.9 m of lithified chalk with green-coated pebbles, several erosion surfaces and four flint seams. The boundary between the *Belemnella obtusa* and *B. sumensis* zones falls within this member.

Little Marl Point Chalk Member

The lower boundary is at the 'greasy marl' with the top at the base of the first soft grey chalk beds labelled 'A' by Peake and Hancock (1970, fig 7). This unit is equivalent to the 'White Chalk with *Ostrea lunata*' of Peake and Hancock (1970). Comprises 5 to 6 m of soft white chalk with four flint seams and two marls. Within the *Belemnella sumensis* Zone of Christensen (1999).

Beacon Hill Grey Chalk Member

Lower boundary bed 'A' by Peake and Hancock (1970, fig 7). Equivalent to the 'Grey Beds' of Peake and Hancock (1970). The member is at least 5 m thick and comprises grey chalk with five flint bands. Within the *Belemnella sumensis* Zone of Christensen (1999).