
British Tertiary stratigraphy

Brian Daley School of Earth, Environmental and Physical Sciences University of Portsmouth Portsmouth, UK

and

Peter Balson British Geological Survey, Keyworth, Nottingham, UK

GCR Editor: L.P. Thomas

Published by the Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough, PE1 1JY UK

First edition 1999

© 1999 Joint Nature Conservation Committee

Typeset in 10/12pt Garamond ITC by JNCC. Printed in Great Britain by Hobbs the Printers Ltd. on 100gsm Silverblade Mau.

ISBN 1 86107 469 7

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the UK Copyright Designs and Patents Act, 1988, this publication may not be reproduced, stored, or transmitted, in any form or by any means, without the prior permission in writing of the publishers, or in the case of reprographic reproduction only in accordance with the terms of the licences issued by the Copyright Licensing Agency in the UK, or in accordance with the terms and licences issued by the appropriate Reproduction Rights Organization outside the UK. Enquiries concerning reproduction outside the terms stated here should be sent to the GCR Team, JNCC.

The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

British Geological Survey Copyright protected materials

1. The copyright of materials derived from the British Geological Survey's work is vested in the Natural Environment Research Council. No part of these materials (geological maps, charts, plans, diagrams, graphs, cross-sections, figures, sketch maps, tables, photographs) may be reproduced or transmitted in any form or by any means, or stored in a retrieval system of any nature, without the written permission of the copyright holder, in advance.
2. To ensure that copyright infringements do not arise, permission has to be obtained from the copyright owner. In the case of BGS maps this includes both BGS and the Ordnance Survey. Most BGS geological maps make use of Ordnance Survey topography (Crown Copyright), and this is acknowledged on BGS maps. Reproduction of Ordnance Survey materials may be independently permitted by the licences issued by Ordnance Survey to many users. Users who do not have an Ordnance Survey licence to reproduce the topography must make their own arrangements with the Ordnance Survey, Copyright Branch, Romsey Road, Southampton SO9 4DH (Tel. 01703 792913).
3. Permission to reproduce BGS materials must be sought in writing from the Copyright Manager, British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG (Tel. 0115 936 3100).

A catalogue record for this book is available from the British Library.

Recommended Example Citations

Balson, P (1999) The Lenham Beds. In *British Tertiary Stratigraphy*, Geological Conservation Review Series No.15, (B Daley and P. Balson). Joint Nature Conservation Committee, Peterborough, pp. 243–252.

Daley, B. (1999) London Basin: eastern localities. In *British Tertiary Stratigraphy*, Geological Conservation Review Series No. 15, (B. Daley and P Balson). Joint Nature Conservation Committee, Peterborough, pp. 23–72.

Contents

Acknowledgements

Access to the countryside Foreword Sir Angus Stirling

Preface B. Daley

1 Introduction to the Tertiary B. Daley

The Tertiary sub-era: subdivision and nomenclature

Understanding the Tertiary

The global context

Tertiary rocks in Britain

2 Introduction to the Palaeogene B. Daley

Economic significance

Palaeogene strata in the British area

History of research

Age and correlation

Palaeogeography

The Palaeogene GCR sites

Key to lithologies and structures

3 London Basin: eastern localities B. Daley

Introduction

Pegwell Bay, Kent

Herne Bay (Bishopstone Cliffs), Kent

Sheppey Cliffs, Kent

Lower Upnor Sand Pit, Kent

Charlton Sand Pit (Gilbert's Pit), Kent

Elmstead Rock Pit, Chislehurst, Kent

Harwich, Essex

Wrabness, Essex

Walton-on-the-Naze, Essex

4 London Basin: western localities B. Daley

Introduction

Harefield, Middlesex

Pincent's Kiln, Theale, Berks

Bolter End, Buckinghamshire

5 Hampshire Basin: Isle of Wight localities B. Daley

Introduction

Whitecliff Bay, Isle of Wight

Alum Bay, Isle of Wight

Headon Hill, Isle of Wight

Colwell Bay, Isle of Wight

Prospect Quarry, Isle of Wight

Bouldnor and Hamstead Cliffs and Foreshore, Isle of Wight

Thorness Bay and Gurnard, Isle of Wight

6 Hampshire Basin: mainland localities B. Daley

Introduction

Studland Bay, Dorset

Bournemouth Cliffs, Dorset

Hengistbury Head, Dorset

Friars Cliff, Mudeford, Dorset

'Barton Cliffs', Hampshire/Dorset

Wittering to Selsey Foreshore, West Sussex

Bognor Regis, West Sussex

Shepherd's Gutter, near Bramshaw, Hampshire

Studley Wood, Hampshire

7 Western outliers of Dorset and Devon B. Daley

Introduction

Blackdown, Dorset

Bincombe Down, Dorset

Creechbarrow, Dorset

Tower Wood Quarry, Devon

Buller's Hill Quarry, Devon

Aller Sand Pit, Devon

8 The Neogene of eastern England P. Batson

Introduction to the Neogene

The Pliocene–Pleistocene Boundary

The Neogene of eastern England

9 The Lenham Beds P. Batson

Introduction

Pivington Quarry, Lenham, Kent

Hart Hill, Kent

10 The Coralline Crag P. Batson

The Craggs of East Anglia

Introduction

Ramsholt Cliff, Ramsholt, Suffolk

Rockhall Wood, Sutton, Suffolk

'The Cliff', Gedgrave, Suffolk

Gedgrave Hall, Gedgrave, Suffolk

Richmond Farm, Gedgrave, Suffolk

Broom Hill, Gedgrave, Suffolk

Sudbourne Park, Sudbourne, Suffolk

Crag Farm, Sudbourne, Suffolk

Valley Farm, Sudbourne, Suffolk

Red House Farm, Iken, Suffolk

Aldeburgh Hall, Aldeburgh, Suffolk

Round Hill, Aldeburgh, Suffolk

Crag Pit Nursery, Aldeburgh, Suffolk

11 The Red Crag P. Balson

Introduction

Hascot Hill Pit, Battisford, Suffolk

Buckanay Farm, Alderton, Suffolk

Bawdsey Cliff, Suffolk

Vale Farm, Sutton, Suffolk

Broom Covert, Butley, Suffolk

Orford Lodge, Chillesford, Suffolk

Waldringfield Heath, Suffolk

Neutral Farm Pit, Butley, Suffolk

Walton-on-the-Naze, Essex

References

Glossary

Index

Acknowledgements

The authors would like to acknowledge the help and encouragement of Bill Wimbledon who first involved them in the site selection phase of the Geological Conservation Review, and who later interested them in writing the Palaeogene (Brian Daley) and Neogene (Peter Balson) parts of what was to become the 'British Tertiary Stratigraphy' GCR volume. Bill's enthusiasm and advice have been welcome over the lengthy period of time that it has taken to bring the project to fruition. Both authors are also grateful to Neil Ellis of JNCC, who more recently provided guidance and support when the decision was made to make a single volume comprising both the Palaeogene and Neogene texts, and particularly during a successful attempt to ensure a more complete coverage of Palaeogene sites than had been originally envisaged. The authors also thank the GCR Publications Team in JNCC, Anita Carter and Neil Cousins, for their work on the production of the book. One of the authors (BD) also thanks Valerie Wyld, formerly of JNCC, for her co-operation and patience in the production of various early versions of the Palaeogene typescript.

Brian Daley is particularly indebted to Nicholas Edwards (Honorary Research Fellow in the University of Portsmouth), who first introduced him to the study of the Palaeogene and with whom he has collaborated for some three decades. His help in the field and constructive editorial skills proved to be of great value. Brian Daley has also benefited greatly from the advice and guidance of Roland Goldring, since commencing research on the Palaeogene under his tutelage, and is also very grateful to Allan Insole with whom he has collaborated for many years. Among the experts on the Palaeogene sites described in this volume, Brian Daley expresses particular thanks to David Bone and Roland Goldring who provided unpublished descriptive material on the sites at Bognor Regis and Pincent's Kiln respectively, and also to Dennis Curry, who has made such a substantial contribution to our understanding of the Tertiary over a period of many decades. Some acknowledgement is also due to Guy Plint and the late Fred Stinton, both of whom submitted site descriptions to the Nature Conservancy Council (NCC) some years ago.

A number of colleagues were kind enough to read over earlier drafts of some of the Palaeogene site descriptions. Particular thanks must go to Nicholas Edwards, Roger Bristow, John Cooper, Dennis Curry, Dick Edwards, Richard Ellison, Roland Goldring, Richard Hamblin, Jerry Hooker, Ed Jarzembowski, Chris King, Jonathan Todd and David Ward (who provided a guided tour of a number of Palaeogene localities in Kent). The support of colleagues at the University of Portsmouth is also much appreciated.

Finally, Brian Daley would like to thank his wife, Pamela, for her consistent encouragement and support.

Peter Balson would like to acknowledge the assistance and numerous contributions which he has received since first becoming interested in the East Anglian Craggs as an undergraduate 25 years ago and subsequently developing this interest as a postgraduate working on the Coralline Crag under the supervision of Martyn Pedley.

In particular he wishes to acknowledge the many useful discussions and contributions from his colleagues at the British Geological Survey and especially from Bernard Humphreys, Steve Mathers and Jan Zalasiewicz both in the office and in the field whilst visiting many of the Red Crag sites described in this volume. He would also like to thank Brian Moorlock for reading and commenting upon a draft of the manuscript.

For many years Bob Markham has provided much useful information on localities and Crag molluscs as well as access to the collections at the Ipswich Museum on innumerable occasions. Arie Janssen, formerly at the National Museum of Natural History in Leiden, provided invaluable assistance to enable the updating of Neogene mollusc names but is not responsible for any errors which may have been introduced by the author. He was also involved in helpful discussions on the topic of the Lenham Beds fauna.

Peter Balson is also particularly indebted to Chris King for assistance and discussions in the field of microfaunas and Neogene stratigraphy of the North Sea Basin.

Finally, Peter Balson would also like to express his particular thanks to Helen Graves for her support and tolerance during difficult times.

Brian Daley and Peter Balson June 1999

Access to the countryside

This volume is not intended for use as a field guide. The description or mention of any site should not be taken as an indication that access to a site is open or that a right of way exists. Most sites described are in private ownership and their inclusion herein is solely for the purpose of justifying their conservation. Their description or appearance on a map in this work should in no way be construed as an invitation to visit. Prior consent for visits should always be obtained from the landowner and/or occupier.

Information on conservation matters, including site ownership, relating to Sites of Special Scientific Interest (SSSIs) or National Nature Reserves (NNRs) in particular counties or districts may be obtained from the relevant country conservation agency headquarters listed below:

Countryside Council for Wales, Plas Penrhos, Ffordd Penrhos, Bangor, Gwynedd LL57 2LQ.

English Nature, Northminster House, Peterborough PE1 1UA.

Scottish Natural Heritage, 12 Hope Terrace, Edinburgh EH9 2AS.

Foreword

So much geology is packed into the piece of the Earth's crust we call 'Britain' that it is hard not to be inspired by the tremendous changes that it has undergone over geological time and the wide variety of environments it has experienced. Deserts, tropical seas, swamps, rivers, ice ages and volcanoes have all left their mark in the rocks and landforms of Britain whilst a wealth of fossils has provided the evidence for contemporary lifeforms and the conditions in which they lived. These rocks, landforms and fossils — our 'Earth heritage' — have been studied and used to demonstrate and test our understanding of Earth processes and Earth history since the earliest days of geological investigations. As a result, Britain has a founding place in the development of the science of geology. Of course, many gaps remain in our knowledge; doubtless, new theories and interpretations will in time be presented to enhance our present understanding and, in some cases, revolutionize it. It is essential that we recognize the contribution that the Earth heritage of Britain has made and will continue to make, and ensure that the most important of Britain's geological localities are conserved for future generations to study, research and enjoy.

It was hard to know where to begin the considerable task of making an inventory of Britain's most important geological and geomorphological sites. Even more demanding was the task of selecting for conservation a set of localities that would adequately represent all the various aspects of our geological heritage and justifying their value for geological research and SSSI status. However, this bold objective was the aim of the Geological Conservation Review (GCR), which began in 1977. In this cause over 200 people have subsequently been involved in selecting and documenting more than 3000 GCR sites covering some 100 different aspects of the Earth sciences. A vast archive of information about these sites has been carefully collected, reviewed and customized to facilitate publication in this series of GCR volumes.

The depth and breadth of the Review has proven to be a world-first for its comprehensiveness. In consequence, many other countries have learnt a great deal from this model and the approach adopted by the GCR contributors.

This volume is the fifteenth to be published in the intended 42 volume GCR series. Not only does it contain the descriptions of key localities that will be conserved for their contribution to our understanding of the Tertiary Period, but also provides an excellent summary of the Tertiary succession in Britain and the considerable research that has been undertaken on it in the latter part of the twentieth century. The volume is a testimony to the sites' importance, justifying their place in the GCR and their ongoing conservation through the SSSI system. I am confident that the book will be invaluable as an essential reference book to those engaged in the study of these rocks and will provide a stimulus for further investigation. It will also be helpful to teachers and lecturers for whom such Tertiary sites are a valuable educational field resource and for those people who, in one way or another, have a vested interest in them: owners, occupiers, planners and indeed the local people for whom such sites are an environmental asset.

The 388 pages of this book represent more than just a publication. An immense body of work has been necessary to arrive at this point — not just the time taken to publish the book, but to research and write it, and further back still, to select the sites for the GCR, a task which began 20 years ago. A large number of sites were assessed and visited, and an essential core — those described in this book were ultimately selected. Since the original site selection phase, the GCR site lists for the Palaeogene and Neogene have not remained static. Seven new Palaeogene Stratigraphy sites were added in 1994 whilst, in keeping with the current interpretation of 'Neogene' in Britain, those 'Crag' sites formerly considered as Pleistocene in age have now been included in the Neogene part of the book.

Dr Brian Daley is to be commended for his long and continuous association with the GCR and in particular for his major role in the development of the 'British Tertiary Stratigraphy' volume since it was first planned in the early 1980s. His work has been important in securing the conservation and documentation of the Palaeogene sites covered in this volume, whilst his forbearance at the decision to delay original publication and widen the scope of the original intended 'Palaeogene Stratigraphy' book to become 'Tertiary Stratigraphy' is much appreciated. Dr Daley is to be congratulated on the breadth of coverage and clarity achieved in his Palaeogene chapters. The sheer size and geological complexity of some of his sites has not made it an easy task to capture the critically important features from each, but he has done an admirable job in evaluating and discussing their importance.

Credit must also go to Dr Peter Balson for the latter part of the book, in providing detailed informative accounts of the Neogene sites. Although these are stratigraphically less extensive than most of the Palaeogene sites and cover shorter periods of geological time (some sites representing days or even hours of sediment deposition!), they nonetheless are important in helping us to understand the development of Neogene Britain and the determination of the Pliocene–Pleistocene boundary.

Both Brian Daley and Peter Balson have provided a great service to conservation and the continuing study of Tertiary rocks in Britain. Furthermore, as the first volume of the Series to be published solely by JNCC, 'British Tertiary Stratigraphy' has a special place for me and my colleagues who serve on the Joint Nature Conservation Committee. It represents our continuing commitment to keeping our geological heritage both valued and properly documented. I look forward to the completion of the GCR Series.

Sir Angus Stirling Chairman, Joint Nature Conservation Committee April 1999

Preface

Although knowledge of the Tertiary geology of the British area has been revolutionized by offshore discoveries consequent upon the search for hydrocarbons, the scientific importance and research potential of the onshore sites in southern and south-eastern England remain undiminished. These sites, some of which are the most stratigraphically extensive of Tertiary sites in western Europe, provide considerable insights into environmental conditions and their evolution on the western margins of the north-west European Palaeogene basin and, later on, Neogene (essentially Pliocene) conditions preceding the onset of glaciation in the Quaternary.

The principle aim of this volume is to provide descriptions and a scientific evaluation of those Tertiary sites assigned GCR status on the grounds of their stratigraphical importance. Following introductions to the Tertiary (Chapter 1) and the Palaeogene (Chapter 2), Chapters 3 to 7 deal with sites of Palaeogene age. Some 34 Palaeogene sites are described, ranging in age from late Palaeocene to early Oligocene. Some are extensive both stratigraphically and geographically and may individually represent many different palaeoenvironments and a depositional history extending over millions of years; by contrast, the smaller sites may represent a particular or even unique facies development and/or biota. Working pits of Palaeogene age exploited by a continuous process of 'cut and fill' such as those in the Ball Clays of Dorset and Devon have not been included in the present volume. Such sites can provide valuable geological data, but are difficult to conserve in a conventional manner. The latter part of the book (Chapters 8 to 11, written by Peter Balson) deals with the Neogene sites, two in Kent and 22 in East Anglia. These contrast in nature with the Palaeogene localities, in that all are restricted both stratigraphically and geographically but together constitute a network of sites providing an opportunity to establish some understanding of vertical and lateral biotic and environmental variation. Of the 24 Neogene sites described, two are from the Lenham Beds, 13 in the Coralline Crag and nine in the Red Crag.

The sites included in this volume are those deemed stratigraphically important on at least a national level. Amongst the criteria used to select them have been their chronostratigraphical and/or lithostratigraphical significance together with their value in palaeoenvironmental, palaeogeographical and palaeoclimatological interpretation. Aspects of sedimentology, macropalaeontology and micropalaeontology are included in the scope of this volume, especially when they have a clearly contributory stratigraphical or environmental significance. However, the evaluation of certain fossil groups represented both at these and other Tertiary sites is considered in more detail elsewhere in palaeontologically thematic GCR volumes.

With few exceptions, the Tertiary stratigraphy sites comprise poorly lithified sequences. A number are coastal cliff sites whose erosion historically provided new exposures and new discoveries but which are now the subject of conflicting interests. In consequence, such developments as 'coastal protection' have already damaged some of these sites and will continue to detract from their geological conservation. The inland sites are also subject to a variety of threats. Some have degraded naturally, whilst others such as former quarries or pits have been used for waste disposal. Such soft lithology sites clearly present a specific set of conservation problems that will need to be continually addressed in order to maintain access for research and educational purposes, an essential facet of our geological heritage.

Brian Daley June 1999

[References](#)