

Deltas

SITES AND TRAPS FOR
FOSSIL FUELS

Geological Society Special Publications

Series Editor K. COE

GEOLOGICAL SOCIETY SPECIAL PUBLICATION NO 41

Deltas

SITES AND TRAPS FOR
FOSSIL FUELS

EDITED BY
M. K. G. WHATELEY & K. T. PICKERING
Department of Geology
The University
Leicester LE1 7RH

1989

Published for
The Geological Society by
Blackwell Scientific Publications

OXFORD LONDON EDINBURGH

BOSTON MELBOURNE

Published for
The Geological Society by
Blackwell Scientific Publications
Osney Mead, Oxford OX2 0EL
(Orders: Tel. 0865-240201)
8 John Street, London WC1N 2ES
23 Ainslie Place, Edinburgh EH3 6AJ
3 Cambridge Center, Suite 208
Cambridge, Massachusetts 02142, USA
107 Barry Street, Carlton, Victoria 3053
Australia

First published 1989

©1989 The Geological Society. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by The Geological Society for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, providing that a base fee of \$03.00 per copy is paid directly to CCC, 27 Congress Street, Salem, MA 01970, USA. 0305-8719/89 \$03.00

Typeset, printed and bound in Great Britain by William Clowes Limited, Beccles and London

DISTRIBUTORS

USA

Publishers' Business Services
PO Box 447
Brookline Village
Massachusetts 02147
(Orders: Tel. (617) 524 7678)

Canada

Oxford University Press
70 Wynford Drive
Don Mills
Ontario M3C 1J9
(Orders: Tel. (416) 441 2941)

Australia

Blackwell Scientific Publications
(Australia) Pty Ltd.
107 Barry Street, Carlton,
Victoria 3053
(Orders: Tel. (03) 347 0300)

British Library Cataloguing in Publication Data

Deltas: sites and traps for fossil fuels.

1. Deltas. Sediments. Fuel deposits.
I. Whateley, M. K. G. II. Pickering, K. T.
Geological Society of London III. Series 551.355
ISBN 0-632-02385-6

Library of Congress Cataloging-in-Publication Data

Deltas: sites and traps for fossil fuels.

(Geological Society special publication; no. 41)
Includes bibliographies and index.
1. Sedimentation and deposition. 2. Deltas.
3. Petroleum—Geology.—I. Whateley, M. K. G.
II. Pickering, K. III. Series.
QE571.D44 1989 553.2'8 88-16827
ISBN 0-632-02385-6

Contents

Preface	vii
WHATELEY, M. K. G. & PICKERING, K. T. Deltas: sites and traps for fossil fuels	ix
Deltaic Systems and General Models	
ELLIOT, T. Deltaic systems and their contribution to an understanding of basin-fill successions	3
ALEXANDER, J. Delta or coastal plain? With an example of the controversy from the Middle Jurassic of Yorkshire	11
SYVITSKI, J. P. M. & FARROW, G. E. Fjord sedimentation as an analogue for small hydrocarbon-bearing fan deltas	21
ITO, M. Profiles of fan deltas and water depth in the receiving basin	45
Subsurface and Geophysical Techniques	
COWAN, G. Diagenesis of Upper Carboniferous sandstones: southern North Sea Basin	57
BRISTOW, C. S. & MYERS, K. J. Detailed sedimentology and gamma-ray log characteristics of a Namurian deltaic succession I: Sedimentology and facies analysis	75
MYERS, K. J. & BRISTOW, C. S. Detailed sedimentology and gamma-ray log characteristics of a Namurian deltaic succession II: Gamma-ray logging	81
SELLEY, R. C. Deltaic reservoir prediction from rotational dipmeter patterns	89
Selected Delta Case Studies	
SESTINI, G. Nile Delta: a review of depositional environments and geological history	99
OKAZAKI, H. & MASUDA, F. Arcuate and bird's foot deltas in the late Pleistocene Palaeo-Tokyo Bay	129
PEDERSEN, G. K. A fluvial-dominated lacustrine delta in a volcanic province, W Greenland	139
HARRIS, J. P. The sedimentology of a Middle Jurassic lagoonal delta system: Elgol Formation (Great Estuarine Group), NW Scotland	147
MARTINSEN, O. J. Styles of soft-sediment deformation on a Namurian (Carboniferous) delta slope, Western Irish Namurian Basin, Ireland	167
PULHAM, A. J. Controls on internal structure and architecture of sandstone bodies within Upper Carboniferous fluvial-dominated deltas, County Clare, western Ireland	179
SIEDLECKA, A., PICKERING, K. T. & EDWARDS, M. B. Upper Proterozoic passive margin deltaic complex, Finnmark, N Norway	205
Petroleum- and Gas-related Case Histories	
FLINT, S., STEWART, D. J. & VAN RIESSEN, E. D. Reservoir geology of the Sirikit oilfield, Thailand: lacustrine deltaic sedimentation in a Tertiary intermontane basin	223
HELLAND-HANSEN, W., STEEL, R., NAKAYAMA, K. & KENDALL, C. G. St. C. Review and computer modelling of the Brent Group stratigraphy	237

BROWN, S. & RICHARDS, P. C. Facies and development of the Middle Jurassic Brent Delta near the northern limit of its progradation, UK North Sea	253
LIVERA, S. E. Facies associations and sand-body geometries in the Ness Formation of the Brent Group, Brent Field	269
Coal-related Case Histories	
HASZELDINE, R. S. Coal reviewed: depositional controls, modern analogues and ancient climates	289
SCOTT, A. C. Deltaic coals: an ecological and palaeobotanical perspective	309
WHATELEY, M. K. G. & JORDAN, G. R. Fan-delta-lacustrine sedimentation and coal development in the Tertiary Ombilin Basin, W Sumatra, Indonesia	317
READ, W. A. The influence of basin subsidence and depositional environment on regional patterns of coal thickness within the Namurian fluvio-deltaic sedimentary fill of the Kincardine Basin, Scotland	333
Index	345

Preface

Deltas, with their economic, political and scientific importance, have long fascinated and attracted Man's attention. The term 'delta' was coined by Herodotus in approximately 450 BC for the triangular-shaped sedimentary body at the mouth of the River Nile. Today, the concept of a delta, its morphology and its controlling processes, are almost as numerous as the people who work on such systems.

This volume, of 23 papers on many aspects of modern and ancient deltaic sedimentary systems, will be useful to researchers as well as teachers and students alike. The well-balanced content of the book should prove particularly attractive to those who seek a detailed state-of-the-science overview of this large and ever-expanding subject area.

The international meeting from which this volume resulted was convened at the Geological Society of London, Burlington House, Piccadilly, from 21 to 22 April 1987, in order to fill the gap in publications on deltaic systems since the flurry of conferences on deltaic sedimentation took place in the early and mid-1970s. We felt that significant advances have been made in our understanding of deltas and yet not collated into a useful reference source, and a timely forum was long overdue to enable workers to disseminate this knowledge. The two-day meeting included 27 papers and eight posters covering modern and ancient deltas in marine to freshwater environments. Topics included processes, facies models, petroleum-, gas- and coal-related deltaic environments, together with general case studies. The meeting attracted about 180 speakers and delegates from Germany, France, Norway, Canada, Italy, Denmark, the USA and Britain. The delegates were warmly welcomed by Professor Alec Smith in his role as Vice-President of the Geological Society. Dr John Hudson stepped in at the eleventh hour to provide a superb after-dinner speech at the conference dinner.

Following the two days of plenary sessions,

there were two successful two-day field trips, one led by Professor Trevor Elliot to the Westphalian of N Devon and the other led by Professor John Collinson to the Namurian of the Pennines. At the weekend following the field trips, there was a one-day core workshop in Edinburgh, organized by Stuart Brown and Philip Richards (British Geological Survey, Edinburgh), to examine the Jurassic Brent cores from the northern North Sea. This was so popular that an additional workshop had to be organized for the following day (Sunday) to cope with demand.

We would like to thank the following companies for their generous sponsorship of the meeting and this publication: Britoil plc, BP Petroleum Development Ltd, Chevron Exploration North Sea Ltd, Clyde Petroleum plc, Enterprise Oil plc, Esso, GAPS Geological Consultants, LASMO Exploration & Production UK Ltd, Neste Oy (Exploration), Norsk Hydro, North Sea Sun Oil Co. Ltd, Occidental International Oil Inc., Occidental Petroleum (Caledonia) Ltd, Robertson Research plc, Teredo Oils Ltd, Texas Eastern North Sea Inc., Total Oil Marine, Tricentrol Oil Corp Ltd and UNOCAL Ltd.

We also wish to thank the Royal Society and the Geological Society of London for their financial support of the meeting. The abstract volume was published by British Gas plc and we thank them for their generosity.

Our thanks to Barbara Afergan, Cherry Walker and Mark Wilkinson for helping us in the many essential operational/administrative tasks on the days of the conference. Sue Button is thanked for last minute drafting of diagrams, and the efficient secretarial staff at the Geological Society and at Leicester University are thanked for their help. Naturally, we thank the authors and the referees of the manuscripts for providing us with the material for this book. Finally we thank our families for their support during the production of this volume.

M. K. G. WHATELEY & K. T. PICKERING, Department of Geology, University of Leicester,
Leicester LE1 7RH, UK.

Deltas: sites and traps for fossil fuels

M. K. G. Whateley & K. T. Pickering

This volume does not aim to review deltas, nor to provide a comprehensive reference source, but merely to highlight some of the recent advances in our knowledge of deltas and their economic significance. The discursive papers by Elliott and Alexander consider the definition of a delta and emphasize the wide spectrum of deltaic and associated deposits. Syvitski and Farrow describe fan deltas in fjords, with their rugged topography and dynamic history of basin infilling as analogues for small hydrocarbon-bearing submarine fans. Ito adds a further dimension to our knowledge of fan deltas and how they relate to water depth in the receiving basin.

A section of the book is devoted to subsurface and geophysical techniques. Cowan considers the porosity evolution of Carboniferous fluvio-deltaic sandstones, and illustrates the importance of understanding poroperm development in these economically attractive reservoirs. The Bristow and Myers combination papers describe how detailed gamma-ray logging, using a potassium, thorium, uranium scintillometer, can be used to distinguish lithofacies associations in a Namurian deltaic succession. This offers the possibility of adding to our already expanding knowledge on facies associations and brings the detailed correlation of surface with subsurface exposure using petrophysical logs. In this respect, Selley's contribution on reservoir prediction using rotational dipmeter patterns complements the previous authors' contributions.

The third section of the book is based around general case studies of various deltaic systems. Sestini provides a review of the sedimentary and tectonic history of the Nile Delta, and Okazaki and Masuda describe Quaternary deltas from palaeo-Tokyo Bay. Pedersen describes the fine-grained sediments in a fluvially dominated lacustrine delta in a volcanic province of W Greenland and highlights the need for provenance studies to understand poroperm and source rock potential better. Siedlecka, Pickering and Edwards document the oldest deltaic system described in this book, from the late Precambrian, N Norway, where wet-sediment deformation is also common. Harris discusses the sedimentology of a Middle Jurassic lagoonal delta system in the Hebrides off

NW Scotland. Papers on Irish Carboniferous deltaic deposits are presented by Martinsen and Pulham. The former deals with styles of wet- or soft-sediment deformation on a Namurian delta slope, whilst Pulham considers the internal structure and architecture of sandstone bodies within the Upper Carboniferous deltaics of County Clare, also containing superb examples of sediment liquefaction and fluidization.

Petroleum- and gas-related case studies form the fourth part of this volume. Flint, Stewart and van Reissen describe the reservoir geology of a lacustrine delta in a Tertiary intermontane basin of the Sirikit oilfield in Thailand and their work shows how important relatively areally restricted basins can be in considerations of oil resource potential. Helland-Hansen, Steel, Nakayama and Kendall investigate sandstone geometry by computer modelling of the Brent Group. This review of the Brent Group is complemented by the papers by Brown and Richards, and Livera, who describe facies associations of formations within the Brent Group. Brown and Richards mainly describe the northern limit of progradation of the Brent Delta, whilst Livera concentrates on sand-body geometry of the Ness Formation.

The final section covers the coal-related case histories in deltaic settings. Haszeldine describes the relationship between depositional controls of coal and coal-bearing strata and climate and structural setting, and points out the need for integrated sedimentological and palaeobotanical studies to enable us to understand fully the relationships between coal and its enclosing sediments. Scott makes similar points, but also shows that modern peat-forming ecosystems require more detailed investigation in order to provide better modern analogues for many ancient coal-related delta systems. Whateley and Jordan consider a thick Tertiary coal deposit in Sumatra, Indonesia, whose geometry appears to be strongly influenced by fan-delta lobes which built out into a lake, the coal forming in interlobe areas. The final paper by Read describes the relationship between subsidence and deposition of fluvio-deltaic environments in the Namurian, Midland Valley, Scotland.

M. K. G. WHATELEY & K. T. PICKERING, Department of Geology, University of Leicester, Leicester LE1 7RH, UK.