Geological Applications of Wireline Logs II

Geological Society Special Publications
Series Editor J. BROOKS

GEOLOGICAL SOCIETY SPECIAL PUBLICATION NO 65

Geological Applications of Wireline Logs II

EDITED BY

A. HURST
Unocal
UK

C. M. GRIFFITHS
University of Trondheim
Norway

P. F. WORTHINGTON
BP Research Centre
UK

1992

Published by

The Geological Society

London

THE GEOLOGICAL SOCIETY

The Society was founded in 1807 as the Geological Society of London and is the oldest geological society in the world. It received its Royal Charter in 1825 for the purpose of 'investigating the mineral structure of the Earth'. The Society is Britain's national learned society for geology with a Fellowship of 7000.

Fellowship is open to those holding a recognized honours degree in geology or cognate subject and who have at least two years relevant postgraduate experience, or have not less than six years relevant experience in geology or a cognate subject. A Fellow who has not less than five years relevant postgraduate experience in the practice of geology may apply for validation and subject to approval will be able to use the designatory letters C. Geol. (Chartered Geologist). Further information about the Society is available from the Membership Manager, Geological Society, Burlington House, London, United Kingdom W1V 0JU.

Published by the Geological Society from:
The Geological Society Publishing House
Unit 7
Brassmill Enterprise Centre
Brassmill Lane
Bath
Avon BA1 3JN
UK
(*Orders*: Tel. 0225 445046)

First published 1992

Distributors
USA
AAPG Bookstore
PO Box 979
Tulsa
Oklahoma 74101-0979
USA
(*Orders*: Tel: (918)584-2555)

Australia
Australian Mineral Foundation
63 Conyngham St
Glenside
South Australia 5065
Australia
(*Orders*: Tel: (08)379-0444)

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library
ISBN 0-903317-80-X

Printed in Great Britain by
Galliard (Printers) Ltd, Great Yarmouth

Contents

Physical properties

Mineralogy and geochemistry

Introduction

A. HURST[1], C. M. GRIFFITHS[2] & P. F. WORTHINGTON[3]

[1] *Unocal UK Ltd, 32 Cadbury Road, Sunbury-on-Thames TW16 7LU, UK (Present address: Department of Geology and Petroleum Geology, Aberdeen University, Aberdeen AB9 2UE, UK)*

[2] *Institute of Petroleum Engineering and Applied Geophysics, University of Trondheim, N-7034 Trondheim, Norway (Present address: BP/Statoil Alliance, Ranheimsveien 10, 7400 Trondheim, Norway)*

[3] *BP Research Centre, Chertsey Road, Sunbury-on-Thames TW16 7LN, UK (Present address: Consultant, 23 Woodlands Ride, Ascot, Berkshire SL5 9HP, UK)*

The contents of this volume provide extensive documentation of the growing diversity of geological problems which can be successfully addressed using wireline log data. From the evidence of this volume, the traditional applications of wireline logs in stratigraphy and sedimentology have continued to grow during the three years since *Geological Applications of Wireline Logs* (GAWL I) in 1988. In contrast, the level of original work using geochemical logs seems to have declined sharply in industrial applications, although remaining significant in the Ocean Drilling Program (ODP). Since GAWL I, high-density/high-resolution log measurements now appear to be an integral part of the characterization of petroleum reservoirs, a trend which, due to the development of slim-hole technology, has been successfully followed by the ODP. Most striking, however, is the increased level of activity focusing on the physical properties of rocks, and the interpretation of measurements made on them. This activity clearly reflects the importance of understanding the interaction between the rock mass and the measuring device before uncritical interpretations are made. It also points to the significance of integrating measurements made at several scales of investigation so as to reveal more of the character of the sub-surface. Finally, there is abundant evidence in this volume for the importance of integrating data of different origin and the potential of multi-disciplinary effort to advance our knowledge. This is of course not unique to geological applications of wireline logs, but an important trend common to all fields of scientific research where rapid progress and discovery are being made.

We hope that this volume will act as a small milestone which records the status of geological applications of wireline logs in the early 1990s. Demand and scientific advances permitting, a future volume in the mid-1990s will provide a further opportunity to evaluate the progress in this exciting field of the geological sciences.

Sedimentology and stratigraphic correlation. **Bourke** documents a procedure for successful sedimentological interpretation of high-density resistivity measurements. **Cameron** presents a methodology for deriving sedimentary orientations from dipmeter data. **Ruhovets *et al.*** document the use of interpretation models for logs with different vertical resolution for their integration with logs with high vertical resolution. Three ODP papers (two by **Salimullah & Stow**, and **Pezard *et al.***) have the interpretation of high-resolution resistivity measurements as key information in their unravelling of the sedimentary history of volcaniclastic facies and regional sedimentological trends respectively. **Slatt *et al.*** illustrate the value of outcrop studies when attempting subsurface correlation and **Hatton *et al.*** illustrate a simple method for correlation in clastic sequences, which include volcaniclastic sediments which may throw new light on the prospectivity of some areas. The remaining paper in this section (**Bølviken *et al.***) presents quantitative methods for automated identification of sedimentary facies and lithologies from wireline logs.

Fractures and stress. Several scales of investigation are described by papers in this section. Basinal, or regional, trends in present day in situ stress orientation derived from borehole breakouts are documented in three papers: **Hillis & Williams** describe stress regimes in the Timor Sea from breakout data; **Yassir & Dusseault** describe similar data from the Ontario cratonic area; **Cowgill *et al.*** provide some preliminary results from the tectonically complex area of the

Witch Ground Graben. Identification of fractures and their character in boreholes is investigated by four papers. Fracture identification, formation and permeability in basement are investigated by **Jackson *et al.***, **Goldberg *et al.*** and **Bremer *et al.*** In the fourth paper, distinction of open fractures and non-sealing faults from breakout data is attempted by **Bell *et al.*** **MacLeod *et al.*** demonstrate the potential for identifying tectonic rotations by integrating high-resolution borehole images and core data, so permitting core orientation without resort to palaeomagnetic data. **Hornby & Luthi** demonstrate the potential for enhancing interpretation of open fractures by integrating measurements made at different scales of investigation using borehole scans and Stoneley waves. Finally, **Adams *et al.*** give an example from the Niger Delta of how the structural interpretation of seismic data may be enhanced by using dipmeter data.

Physical properties. Excluding the papers on in situ stress, seven papers address diverse aspects of other physical properties of rocks. Two papers investigate seismic properties. **McCann & Sothcott** report the laboratory measurement of velocity and attenuation using a single-frequency pulsed sine wave. **Raaen** demonstrates derivation of shear velocity from pseudo-Rayleigh waves. Aspects of thermal properties are the basis of two papers, first the presentation of temperature decay logs (**Alm**), and second an evaluation of the prediction of thermal conductivity from wireline log suites (**Griffiths *et al.***). In a geotechnical evaluation, **McCann & Entwisle** discuss the in situ determination of Young's modulus of the rock mass from wireline logs. **Ølgaard** presents a new rationale for the interpretation of nuclear log measurements. Data from a regional North Sea well log database, calibrated with known pore fluid compositions, provide the basis for a study of salinity variations in various oil fields and allow inferences to be made regarding basin fluid dynamics (**Gran *et al.***).

Mineralogy and geochemistry. Despite the relatively recent advent of wireline logs that allow downhole measurement of geochemical parameters (see GAWL I), only a single ODP paper (**Harvey & Lovell**) investigates the interpretation of these data, drawing attention to the problem of compositional co-linearity in mineral inversion. The other papers investigate mineralogical and geochemical problems without resort to downhole geochemical parameters. **Selley** identifies the potential for detailed sandstone diagenetic studies using logs, **Myers & Jenkyns** describe an efficient and accurate, field-tested method for determining the total organic carbon content of hydrocarbon source rocks which uses only conventional log data, which is apparently more accurate than alternative methods using geochemical log data, and **Cheshire & Sellwood** presents a forward modelling approach to the determination of the diagenetic characteristics of sandstones.

We would like to thank the independent referees and authors who undertook refereeing as part of their commitment to the publication of this volume. Without the help of the following we could not have attained the high scientific quality which was our goal: J. T. Adams, A. Adamson, J. S. Bell, L. T. Bourke, R. Brereton, E. Bølviken, G. I. F. Cameron, T. J. Chapman, M. J. Cheshire, M. B. Dusseault, C. J. Evans, E. Fjær, D. Goldberg, P. K. Harvey, C. Hermanrud, M. M. Herron, R. Hillis, R. Holt, B. E. Hornby, J. J. Howard, P. D. Jackson, J. L. Jensen, J. D. Kantorowicz, D. Kassenaar, M. King, J. Kulenkampf, S. R. Lawrence, M. A. Lovell, S. Luthi, P. Lysne, K. Mandziuch, R. Marsden, M. Matthews, C. McCann, D. M. McCann, D. Moos, B. P. Moss, K. J. Myers, O. Olsson, J. Owens, L. M. Parson, V. Patel, P. A. Pezard, A. M. Raaen, S. Raikes, M. H. Rider, M. Sams, R. C. Selley, R. M. Slatt, H. Smith, B. Steingrimsson, A. E. Stocks, D. A. V. Stow, J. Tittman, B. Twombley, J. R. Underhill, J. J. Walsh, J. Ward, H. Williams, M. Worthington, N. Yassir and G. Yielding.