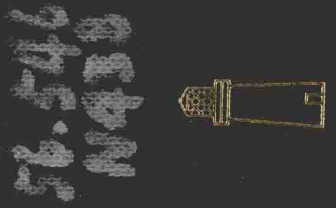
NEOTECTONICS AND RESOURCES

EDITED BY JOHN COSGROVE & MERVYN JONES



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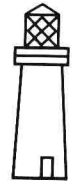

Belhaven Press
(a division of Pinter Publishers)
London and New York

First published in Great Britain in 1991 by
Belhaven Press (a division of Pinter Publishers),
25 Floral Street, London WC2E 9DS

British Library Cataloguing in Publication Data
A CIP catalogue record for this book is available from the
British Library

ISBN 1 85293 075 6

Library of Congress Cataloging in Publication Data

Neotectonics and resources/edited by Mervyn Jones and John Cosgrove.
p. cm.
Includes bibliographical references and index.
ISBN 1-85293-075-6
1. Neotectonics. 2. Mines and mineral resources. 3. Geology.
I. Jones, M.E. (Mervyn E.) II. Cosgrove, J.W. (John W.)
QE511.42.N45 1991
551.8-dc20 91-14592
CIP

Typeset by Mayhew Typesetting, Bristol, England
Printed in Great Britain by SRP Ltd., Exeter

Neotectonics and Resources

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Preface

This volume contains the proceedings of the second Sino-British Geological Conference. The meeting, entitled 'Economic Geology and Geotechnics of Active Tectonic Regions', was hosted by the Department of Geological Sciences at University College London in April 1989 and the papers presented covered a wide variety of topics relating to neotectonics. Nevertheless, they can be conveniently divided into four categories, namely: 'The general geology of neotectonic environments', 'Geomorphology, earthquakes and slope stability in neotectonic environments', 'Economic geology of neotectonic regions', and 'Engineering geology in neotectonic terrains'. It is in this grouping that the contributions are presented in this volume. Each of the four parts is preceded by a short introduction which outlines the scope of the part and gives an overview of the chapters it contains.

Part One opens with a discussion of the stratigraphy of active tectonic regions and the generation of high fluid pressures during sedimentation and diagenesis, and this is followed by an extensive review of the influence of fluid pressure on the deformation behaviour of sediments and partially lithified rocks. Subsequent chapters demonstrate how structural landforms can be used to detect the southward propagation of the Coastal Range of Eastern Taiwan as a result of the oblique collision between the Eurasian and Philippine plates and how the numerous raised beaches preserved along the coast can be used to determine the detailed evolution and elevation of the Coastal Range during the Holocene.

Part Two begins with a discussion of the mechanisms proposed for the formation of 'accordant summits', a phenomenon that can be observed in many mountain chains. It is convincingly argued that the generation of accordant summits is directly linked to the dynamics of plate collision. Three chapters in this section consider seismic activity in the Mediterranean. One assesses the validity of seismic records from the nineteenth century and the others describe a simple technique that enables landform stability to be monitored in seismically active regions and shows how, by the careful mapping of seismically induced structures, urban planning of an area can be adapted to minimize earthquake damage.

The results of experiments designed to record the build up and dissipation of pore water pressure during earthquakes are presented and the influence of high fluid pressure and rock type on slope stability considered. A review of the various factors affecting the generation of different types of 'mass flows' is given, particular attention being paid to the influence of the degree of compaction and of transient fluid pressures which can arise as a result of seismic activity. The part closes with a description of a model designed to predict the landslide potential of a region by attempting to quantify the various factors which contribute to the generation of gravitational instability.

Part Three focuses on some of the economic aspects of neotectonic environments. The first three chapters consider the problems associated with hydrocarbon prospecting in regions of active tectonism and the fourth looks at the migration and concentration of fluids within a deforming sedimentary pile such as an accretionary prism. Other chapters consider the influence of present-day tectonic activity on the formation of gold deposits and marble belts, and the part ends with a discussion of the use of remote sensing in geothermal exploration in two neotectonic environments in the USA.

In the final part some of the problems encountered by engineering geologists working in neotectonic terrains are considered. A case history of slope stabilization associated with the construction of a major reservoir is given and the influence of geological factors on the design of a power cavern and a diversion tunnel are described. The degradation of soil as a result of earthquake activity is quantified using the experimental data on pore fluid pressure variations during seismic events discussed in Part Two. The part ends with two chapters on the influence of ground water exploitation on land subsidence. The first is a case study from the Tokyo Bay area of Japan and the second a theoretical description of land subsidence due to pumping.

Although a wide range of topics is covered in this volume it does not of course present a comprehensive coverage of all aspects of neotectonics. However, every effort has been made to present the contributions in a logical and coherent manner which, it is hoped, will provide the reader with a new insight into the geological and geomorphological processes operating in neotectonic environments.

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March 1991

Acknowledgements

We are indebted to the numerous people who contributed towards the organization and running of the second Sino-British Geological Conference, the proceedings of which are summarized in this volume. Our especial thanks go to the National Science Council of Taiwan who generously funded many of the delegates, to Marconi Oceonics and the Sedimentary Deformation Research group at University College who acted as joint sponsors, and to the Department of Geological Sciences at University College for hosting the conference.

Contents

Part One

Aspects of the general geology and geomorphology of neotectonic environments

Introduction

The papers presented in Part One relate to geological and geomorphological processes occurring at active plate margins. It opens with a discussion of 'The Role of Stratigraphy in Neotectonics', where it is argued that statements commonly made as accepted truths such as 'Anticlines are formed by lateral compression', 'Regressive sequences record uplift of the sedimentary basin', 'Faults and folds are younger than the rocks folded or faulted', 'Reverse faults are evidence of lateral compression' and 'Subsurface fluids tend to move upwards because that is the direction of the reduced pressure' are incomplete or in error. Each statement is a partial truth, but the exceptions are so important that they cannot be ignored. These exceptions become particularly apparent in neotectonic environments where plate collision causes increase in sediment supply which in turn causes a regressive sequence. This sequence is mechanically unstable, with the result that structures such as folds, faults and mud volcanoes develop. The formation of these structures, particularly mud volcanoes, is frequently the result of abnormally high fluid pressures, and the cause and effect of excess pore fluid pressures in active tectonic regions is the subject of Chapter 2.

The sedimentary environments developed at a plate margin will sensitively reflect the detailed tectonic history of that margin. This is convincingly demonstrated in Chapter 3, which compares the sedimentology of shallow-water limestones developed in two active tectonic regions — Costa Rica and eastern Taiwan. The mechanisms by which the shelves on which these two limestones were formed are different, the Costa Rican limestone being deposited on obducted oceanic crust and the limestone from eastern Taiwan on volcanic islands. These differences can be deduced by a careful study of the two rocks.

The Coastal Range of eastern Taiwan formed at the junction of the Eurasian and Philippine plates. Within such an active tectonic environment, the landforms and topography closely reflect the interaction of the tectonic system with the near-surface processes of weathering and denudation. Chapter 4 proposes a model for the evolution of the Coastal Range based on information that can be gained from the drainage pattern and the tectonic fabric of the landform. Because this work uses landforms to determine uplift patterns, locations and rates it can also be used to extend the current seismological record back in time.

The Coastal Range of eastern Taiwan is characterized by rapid uplift rates and in Chapter 5 an attempt is made to quantify the recent uplift history by studying the age and present altitudes of the various Holocene terraces which are preserved on the Pacific side of this mountain range. The study reveals an uplift rate along the coast which varies in the range 3–13 mm yr^{-1}.

The study of uplift rates in the Coastal Range gives data relating to the most recent events associated with plate collision in eastern Taiwan. However, a tectonic analysis of the geological structures of the Hsueshan mountain range in central Taiwan reveals the deformation history of this plate margin over a much longer time period. Chapter 6 describes this study and shows that synsedimentary extensional features such as normal faults which were probably related to the rifting of the South China Sea basin, have been overprinted with a variety of compressional features associated with subsequent plate collision.

The morphology of normal fault scarps in neotectonic environments is the subject of Chapter 7. The study concentrates on normal fault scarps underlain by carbonate bedrock in the Greek and Turkish sectors of the Aegean extensional province and compares these with the Range front fault scarps of the Basin and Range province in the western United States.

Part One ends with an intriguing study of the induced magnetic field generated during faulting. The analysis presented is of movement on a horizontal fault (for example, the extensive flat regions of a ramp/flat thrust system). It is shown that the magnetism induced is directly proportional to the area of slip and inversely proportional to the depth of the fault. The analysis is at present being extended to include normal and reverse faults.

Chapter 1
The role of stratigraphy in neotectonics

R.E. Chapman

Geology was founded on the study of outcrops, coalmines, canals and railway cuttings in the nineteenth century, and it has not been revised sufficiently in the twentieth century in the light of the geology of oilfields as revealed by boreholes. The concepts of sedimentary basins, as distinct from geosynclines, have received very little attention in spite of the wealth of data. Several statements that are commonly made as accepted truth are incomplete or in error:

- 'Anticlines are formed by lateral compression'.
- 'Regressive sequences record uplift of the sedimentary basin'.
- 'Faults and folds are younger than the rocks folded or faulted'.
- 'Reverse faults are evidence of lateral compression'.
- 'Subsurface fluids tend to move upwards because that is the direction of reduced pressure'.

Each of these statements is a partial truth, but the exceptions are so important that they cannot be ignored. They should all be revised to include the exceptions.

- 'Anticlines can be formed in stress fields with a component of lateral tension as well as in those with a component of lateral compression; and their axes tend to be normal to the least principal stress (the greatest being vertical)' (see Tanner and Williams, 1968).
- 'Regressive sequences indicate uplift outside the sedimentary basin' or 'Regressive sequences accumulate while the sedimentary column is subsiding, the sediment being supplied from an orogeny or uplift that may be far from the sedimentary basin'.
- 'Faults and folds are not older than the rocks faulted or folded'.
- 'Reverse faults with dips of approximately 60° can be formed in the same stress field as normal faults'.
- 'Subsurface fluids move in the direction of reduced energy, which may be in any direction'.

The first four, perhaps five, are important in the understanding of neotectonics because they emphasize at least one aspect of neotectonics that is only indirectly related to tectonics — which is that orogeny (mountain-building) causes increased sediment supply that causes the regressive sequence that is mechanically unstable and causes structures such as folding, faulting and mud volcanism.