

Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya

Geological Society Special Publications

Series Editors

A. J. HARTLEY
R. E. HOLDSWORTH
A. C. MORTON
M. S. STOKER

Special Publication reviewing procedure

The Society makes every effort to ensure that the scientific and production quality of its books matches that of its journals. Since 1997, all book proposals have been refereed by specialist reviewers as well as by the Society's Publications Committee. If the referees identify weaknesses in the proposal, these must be addressed before the proposal is accepted.

Once the book is accepted, the Society has a team of series editors (listed above) who ensure that the volume editors follow strict guidelines on refereeing and quality control. We insist that individual papers can only be accepted after satisfactory review by two independent referees. The questions on the review forms are similar to those for *Journal of the Geological Society*. The referees' forms and comments must be available to the Society's series editors on request.

Although many of the books result from meetings, the editors are expected to commission papers that were not presented at the meeting to ensure that the book provides a balanced coverage of the subject. Being accepted for presentation at the meeting does not guarantee inclusion in the book.

Geological Society Special Publications are included in the ISI Science Citation Index, but they do not have an impact factor, the latter being applicable only to journals.

More information about submitting a proposal and producing a Special Publication can be found on the Society's web site: www.geolsoc.org.uk

It is recommended that reference to all or part of this book should be made in one of the following ways.

KHAN, M. A., TRELOAR, P. J., SEARLE, M. P. & JAN, M. Q. (eds) 2000. *Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya*. Geological Society, London, Special Publications, **170**.

WHITTINGTON, A., HARRIS, N. B. W., AYRES, M. W. & FOSTER, G. 2000. Tracing the origins of the western Himalaya: an isotopic comparison of the Nanga Parbat Massif and Zaskar Himalaya. *In*: KHAN, M. A., TRELOAR, P. J., SEARLE, M. P. & JAN, M. Q. (eds) *Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya*. Geological Society, London, Special Publications, **170**, 201–218.

GEOLOGICAL SOCIETY SPECIAL PUBLICATION NO. 170

Tectonics of the Nanga Parbat Syntaxis and the Western Himalaya

EDITED BY

M. ASIF KHAN
University of Peshawar, Pakistan

PETER J. TRELOAR
Kingston University, UK

MICHAEL P. SEARLE
Oxford University, UK

and

M. QASIM JAN
University of Peshawar, Pakistan

2000
Published by
The Geological Society
London

THE GEOLOGICAL SOCIETY

The Geological Society of London was founded in 1807 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' and is now Britain's national society for geology.

Both a learned society and a professional body, the Geological Society is recognized by the Department of Trade and Industry (DTI) as the chartering authority for geoscience, able to award Chartered Geologist status upon appropriately qualified Fellows. The Society has a membership of 8600, of whom about 1500 live outside the UK.

Fellowship of the Society is open to persons holding a recognized honours degree in geology or a cognate subject and who have at least two years' relevant postgraduate experience, or not less than six years' relevant experience in geology or a cognate subject. A Fellow with a minimum of five years' relevant postgraduate experience in the practice of geology may apply for chartered status. Successful applicants are entitled to use the designatory postnominal CGeol (Chartered Geologist). Fellows of the Society may use the letters FGS. Other grades of membership are available to members not yet qualifying for Fellowship.

The Society has its own Publishing House based in Bath, UK. It produces the Society's international journals, books and maps, and is the European distributor for publications of the American Association of Petroleum Geologists (AAPG), the Society for Sedimentary Geology (SEPM) and the Geological Society of America (GSA). Members of the Society can buy books at considerable discounts. The Publishing House has an online bookshop (<http://bookshop.geolsoc.org.uk>).

Further information on Society membership may be obtained from the Membership Services Manager, The Geological Society, Burlington House, Piccadilly, London W1V 0JU (Email: enquiries@geolsoc.org.uk; tel: +44 (0)171 434 9944).

The Society's Web Site can be found at <http://www.geolsoc.org.uk/>. The Society is a Registered Charity, number 210161.

Published by The Geological Society from:

The Geological Society Publishing House

Unit 7, Brassmill Enterprise Centre

Brassmill Lane

Bath BA1 3JN, UK

Orders: Tel. +44 (0)1225 445046

Fax +44 (0)1225 442836

Online bookshop: <http://bookshop.geolsoc.org.uk>

First published 2000

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

© The Geological Society of London 2000. All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission. No paragraph of this publication may be reproduced, copied or transmitted save with the provisions of the Copyright Licensing Agency, 90 Tottenham Court Road, London W1P 9HE. Users registered with the Copyright Clearance Center, 27 Congress Street, Salem, MA 01970, USA: the item-fee code for this publication is 0305-8719/00/\$15.00.

British Library Cataloguing in Publication Data

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

ISBN 1-86239-061-4

ISSN 0305-8719

Typeset by WKS, Westonzoyland, UK

Printed by Hobbs the Printers, Southampton, UK

Distributors

USA

AAPG Bookstore

PO Box 979

Tulsa

OK 74101-0979

USA

Orders: Tel. +1 918 584-2555

Fax +1 918 560-2652

Email bookstore@aapg.org

Australia

Australian Mineral Foundation Bookshop

63 Conyngham Street

Glenside

South Australia 5065

Australia

Orders: Tel. +61 88 379-0444

Fax +61 88 379-4634

Email bookshop@amf.com.au

India

Affiliated East-West Press PVT Ltd

G-1/16 Ansari Road, Daryaganj,

New Delhi 110 002

India

Orders: Tel. +91 11 327-9113

Fax +91 11 326-0538

Japan

Kanda Book Trading Co.

Cityhouse Tama 204

Tsurumaki 1-3-10

Tama-shi

Tokyo 206-0034

Japan

Orders: Tel. +81 (0)423 57-7650

Fax +81 (0)423 57-7651

Contents

Acknowledgements	vii
TRELOAR, P. J., SEARLE, M. P., KHAN, M. A. & JAN, M. Q. Tectonics of the Nanga Parbat syntaxis and the western Himalaya: an introduction	1
CAPORALI, A. The gravity field of the Karakoram Mountain Range and surrounding areas	7
TRELOAR, P. J., GEORGE M. T. & WHITTINGTON, A. G. Mafic sheets from Indian plate gneisses in the Nanga Parbat syntaxis: their significance in dating crustal growth and metamorphic and deformation events	25
BUTLER, R. W. H. Structural evolution of the western margin of the Nanga Parbat massif, Pakistan Himalaya: insights from the Raikhot–Liachar area	51
EDWARDS, M. A., KIDD, W. S. F., KHAN, M. A. & SCHNEIDER, D. A. Tectonics of the SW margin of the Nanga Parbat–Haramosh massif	77
ARGLES, T. W. The evolution of the Main Mantle Thrust in the Western Syntaxis, Northern Pakistan	101
BUTLER, R. W. H., WHEELER, J., TRELOAR, P. J. & JONES, C. Geological structure of the southern part of the Nanga Parbat massif, Pakistan Himalaya, and its tectonic implications	123
TRELOAR, P. J., REX, D. C., GUISE, P. G., WHEELER, J., HURFORD, A. J. & CARTER, A. Geochronological constraints on the evolution of the Nanga Parbat syntaxis, Pakistan Himalaya	137
SHRODER, J. F. & BISHOP, M. P. Unroofing of the Nanga Parbat Himalaya	163
BISHOP, M. P. & SHRODER, J. F. Remote sensing and geomorphometric assessment of topographic complexity and erosion dynamics in the Nanga Parbat massif	181
WHITTINGTON, A., HARRIS, N. B. W., AYRES, M. W. & FOSTER, G. Tracing the origins of the western Himalaya: an isotopic comparison of the Nanga Parbat massif and Zaskar Himalaya	201
BURG, J.-P. & PODLADCHIKOV, Y. From buckling to asymmetric folding of the continental lithosphere: numerical modelling and application to the Himalayan syntaxes	219
ZANCHI, A., POLI, S., FUMAGALLI, P. & GAETANI, M. Mantle exhumation along the Tirich Mir Fault Zone, NW Pakistan: pre-mid-Cretaceous accretion of the Karakoram terrane to the Asian margin	237
WEINBERG, R. F., DUNLAP, W. J. & WHITEHOUSE, M. New field, structural and geochronological data from the Shyok and Nubra valleys, northern Ladakh: linking Kohistan to Tibet	253
HILDEBRAND, P. R., SEARLE, M. P., SHAKIRULLAH, ZAFARALI KHAN & VAN HEIJST, H. J. Geological evolution of the Hindu Kush, NW Frontier Pakistan: active margin to continent–continent collision zone	277
ARBARET, L., BURG, J.-P., ZEILINGER, G., CHAUDHRY, N., HUSSAIN, S. & DAWOOD, H. Pre-collisional anastomosing shear zones in the Kohistan ark, NW Pakistan	295
YAMAMOTO, H. & NAKAMURA, E. Timing of magmatic and metamorphic events in the Jijal complex of the Kohistan arc deduced from Sm–Nd dating of mafic granulites	313
ANCZKIEWICZ, R. & VANCE, D. Isotopic constraints on the evolution of metamorphic conditions in the Jijal–Patan complex and the Kamila Belt of the Kohistan arc, Pakistan Himalaya	321
ROBERTSON, A. H. F. Formation of mélanges in the Indus Suture Zone, Ladakh Himalaya by successive subduction-related, collisional and post-collisional processes during Late Mesozoic–Late Tertiary time	333

DiPIETRO, J. A., HUSSAIN, A., AHMAD, I. & KHAN, M. A. The Main Mantle Thrust in Pakistan: its character and extent	375
CORFIELD, R. I. & SEARLE, M. P. Crustal shortening estimates across the north Indian continental margin, Ladakh, NW India	395
LOMBARDO, B., ROLFO R. & COMPAGNONI, R. Glaucophane and barroisite eclogites from the Upper Kaghan nappe: implications for the metamorphic history of the NW Himalaya	411
FONTAN, D., SCHOUPPE, M., HUNZIKER, C. J., MARTINOTTI, G. & VERKAERAN, J. Metamorphic evolution, ^{40}Ar - ^{39}Ar chronology and tectonic model for the Neelum valley, Azad Kashmir, NE Pakistan	431
ABBASI, I. A. & FRIEND, P. F. Exotic conglomerates of the Neogene Siwalik succession and their implications for the tectonic and topographic evolution of the Western Himalaya	455
BADSHAH, M. S., GNOS, E., JAN, M. Q. & AFRIDI, M. I. Stratigraphic and tectonic evolution of the northwestern Indian plate and Kabul Block	467
Index	477

Acknowledgements

The papers in this volume arise from the thirteenth Himalaya–Karakoram–Tibet workshop held in the University of Peshawar, Pakistan on 20–22 April 1998. The meeting was convened by M. Asif Khan and M. Qasim Jan. Peter Treloar wishes to express admiration to Pam Nieto for, yet again, permitting her home to be overrun by mountains of Geological Society-related paperwork (see Geological Society of London Special Publications Numbers 74 and 138).

We also express our thanks to Bob Holdsworth and the Tectonic Studies Group for partial funding for the reproduction of the colour fold-out maps for the Hildebrand *et al.* and Corfield & Searle papers in this volume.

The editors wish to acknowledge reviews by the following geoscientists:

R. Anckiewicz	R. J. Lisle
L. Arbaret	K. J. McCaffrey
T. W. Argles	J. Miller
J.-P. Burg	P. J. O'Brien
R. W. H. Butler	A. I. Okay
P. R. Cobbold	Y. M. R. Najman
S. J. Cuthbert	R. R. Parrish
S. M. de Bari	M. G. Petterson
P. D. Clift	L. Ratschbacher
W. D. Cunningham	H. G. Reading
G. R. Davies	A. Richards
T. Dempster	A. H. F. Robertson
E. Derbyshire	H. R. Rollinson
J. A. DiPietro	D. Rust
M. A. Edwards	J. W. Shervais
E. Fielding	R. A. Strachan
C. R. L. Friend	I. M. Villa
M. Gaetani	J. D. Vitek
M. T. George	D. J. Waters
J. Grocott	J. Wheeler
D. Haddad	B. F. Windley
N. B. W. Harris	A. G. Whittington
P. R. Hildebrand	H. Yamamoto
M. S. Hubbard	A. Zanchi
S. H. Lamb	P. K. Zeitler
R. D. Law	