TRANSACTIONS OF THE ROYAL SOCIETY OF EDINBURGH



EARTH SCIENCES

Volume 88 Part 3

PUBLISHED BY THE RSE SCOTLAND FOUNDATION 22 GEORGE STREET · EDINBURGH · EH2 2PQ

1998 (for 1997)

The Royal Society of Edinburgh is committed to the widespread dissemination of scientific knowledge. Through the *Transactions* of the Royal Society of Edinburgh: Earth Sciences, the Society continues to encourage and support the international Earth Sciences community by:

- publishing a journal of international standing and authorship;
- publishing substantial papers on all scientific aspects of the solid earth and its surfaces;
- publishing without page charges;
- reproducing photographs and artwork to the highest standard, where appropriate at a size larger than is customary; and
- having papers reviewed by two referees of international standing within three months, and usually publishing within six months of receipt of revised papers.

Editorial Board

J. MCMANUS University of St Andrews (Chairman)

E. N. K. CLARKSON University of Edinburgh (*Executive Editor*)

C. M. CLAPPERTON University of Aberdeen

A. E. FALLICK S.U.R.R.C., East Kilbride

J. H. HULL British Geological Survey, Edinburgh

A. H. F. ROBERTSON University of Edinburgh D. J. FETTES British Geological Survey (*Executive Editor*)

A. B. SMITH Natural History Museum (*Executive Editor*)

T. P. SCOFFIN University of Edinburgh

W. E. STEPHENS University of St Andrews

M. ANDERSON University of Edinburgh (*Curator*)

SHOHEI BANNO Kyoto University

W. L. BROWN Centre de Recherches Pétrographiques et Géochimiques, Vandoeuvre-les-Nancy

R. L. CARROLL McGill University, Montreal

B. W. CHAPPELL Australian National University, Canberra

J. M. COLEMAN Louisiana State University, Baton Rouge **Consulting Editors**

J. F. DEWEY University of Oxford

S. J. GOULD University of Harvard

R. W. HUTCHINSON Colorado School of Mines J. KONTA

Charles University, Prague D. B. MCINTYRE

Kinfauns, Perth

K. J. MÜLLER Rhein. Friedrich-Wilhelms-Universität Bonn D. F. STRONG University of Victoria, B.C.

V. C. THAKUR Wadia Institute of Himalayan Geology

S. UYEDA University of Tokyo

R. WOODALL Western Mining Co., Adelaide

Publications Officer: Royal Society of Edinburgh: Vicki Ingpen

COPYRIGHT: It is the policy of the Royal Society of Edinburgh not to charge any royalty for the production of a single copy of any one article made for private study or research. Specific permission will not be required for photocopying multiple copies of copyright material, to be used for *bona fide* educational purposes, provided this is done by a member of the staff of the university, school or other comparable institution, for distribution without profit to student members of that institution and provided the copies are made from the original journal. Requests for the copying or reprinting of any article for any other purpose should be sent to the Royal Society of Edinburgh.

Transactions of the Royal Society of Edinburgh: Earth Sciences publishes one volume per year, usually in three or four parts. Volume 89 (1998) will be published in four issues. An annual subscription costs £104, or \$170. Orders should be placed with CAB International (to whom cheques should be made payable), Wallingford, Oxon OX10 8DE, UK. (Tel 01491 832111; Fax 01491 826090; email: f.denyar@cabi.org)

Transactions is indexed in the following: Current Contents/Physical, Chemical & Earth Sciences, SciSearch, CABS Database, Mineralogical Abstracts, Biosciences Information Service, Geoabstracts and GEOBASE.

© 1998 The Royal Society of Edinburgh.