THE FOURTH HUTTON SYMPOSIUM ON THE ORIGIN OF GRANITES AND RELATED ROCKS

TRANSACTIONS OF The Royal Society OF Edinburgh



EARTH SCIENCES

Volume 91 Parts 1 and 2

PUBLISHED BY THE RSE SCOTLAND FOUNDATION 22–26 GEORGE STREET • EDINBURGH • EH2 2PQ 2000 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

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

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

S. L. HARLEY University of Edinburgh

R. MacDONALD University of Lancaster

J. McMANUS University of St Andrews

I. PARSONS University of Edinburgh W. E. STEPHENS University of St Andrews (*Executive Editor*)

M. F. THOMAS University of Stirling (*Executive Editor*)

R. A. SCRUTTON University of Edinburgh

A. WERRITTY University of Dundee

M. D. McLEOD (*Curator*)

Consulting Editors

J. F. DEWEY University of Oxford

University of Harvard

R. W. HUTCHINSON

Colorado School of Mines

Charles University, Prague

D. B. MCINTYRE

S. J. GOULD

J. KONTA

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

n Rouge Kinfauns, Perth Western Min

Journals Officer: Royal Society of Edinburgh: Vicki M. 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 91 (2000) will be published in two parts: (two double symposium issues). An annual subscription costs £120, or \$195. Orders should be placed with CAB International (to whom cheques should be made payable), Wallingford, Oxon OX10 8DE, UK. (Tel 01491 832111; Fax 01491 829292; email: orders@cabi.org).

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

©2001 The Royal Society of Edinburgh.

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

Fourth Hutton Symposium The Origin of Granites and Related Rocks

Proceedings of a Symposium held in Clermont-Ferrand, France 20–25 September, 1999

Edited by B. Barbarin, W. E. Stephens, B. Bonin, J-L. Bouchez, D. B. Clarke, M. Cuney and H. Martin

Printed by J.W. Arrowsmith Ltd, Bristol, UK

CONTENTS

Ed STEPHENS and Bernard BARBARIN Preface	v
Peter I. NABELEK and Cindy D. BARTLETT Fertility of metapelites and metagraywackes during leucogranite generation: an example from the Black Hills, U.S.A.	1
Vojtěch JANOUŠEK, D. R. BOWES, Colin J. R. BRAITHWAITE and Graeme ROGERS Microstructural and mineralogical evidence for limited involvement of magma mixing in the petrogenesis of a Hercynian high-K calc-alkaline intrusion: the Kozárovice granodiorite, Central Bohemian Pluton, Czech Republic	15
W. J. COLLINS, S. R. RICHARDS, B. E. HEALY and P. I. ELLISON Origin of heterogeneous mafic enclaves by two-stage hybridisation in magma conduits (dykes) below and in granitic magma chambers	27
Takehiro KOYAGUCHI and Katsuya KANEKO Thermal evolution of silicic magma chambers after basalt replenishments	47
Bruno SCAILLET, Alan WHITTINGTON, Caroline MARTEL, Michel PICHAVANT and François HOLTZ Phase equilibrium constraints on the viscosity of silicic magmas II: implications for mafic-silicic mixing processes	61
E. W. SAWYER Grain-scale and outcrop-scale distribution and movement of melt in a crystallising granite	73
Nick PETFORD Dyke widths and ascent rates of silicic magmas on Venus	87
Laurent ARBARET, Angel FERNANDEZ, Josef JEŽEK, Benoît ILDEFONSE, Patrick LAUNEAU and Hervé DIOT Analogue and numerical modelling of shape fabrics: application to strain and flow determination in magmas	97
Keith BENN, Francis ODONNE, Sharon K. Y. LEE and Ken DARCOVICH Analogue scale models of pluton emplacement during transpression in brittle and ductile crust	111
H. SANT'OVAIA, J. L. BOUCHEZ, F. NORONHA, D. LEBLANC and J. L. VIGNERESSE Composite-laccolith emplacement of the post-tectonic Vila Pouca de Aguiar granite pluton (northern Portugal): a combined AMS and gravity study	123
John P. HOGAN, M. Charles GILBERT and Jon D. PRICE Crystallisation of fine- and coarse-grained A-type granite sheets of the Southern Oklahoma Aulacogen, U.S.A.	139
R. J. PANKHURST, C. W. RAPELA and C. M. FANNING Age and origin of coeval TTG, I- and S-type granites in the Famatinian Belt of NW Argentina	151
M. A. PARADA, A. LAHSEN and C. PALACIOS The Miocene plutonic event of the Patagonian Batholith at 44° 30′ S: thermochronological and geobarometric evidence for melting of a rapidly exhumed lower crust	169
Bor-ming JAHN, Fuyuan WU and Bin CHEN Granitoids of the Central Asian Orogenic Belt and continental growth in the Phanerozoic	181
Cheng-Hong CHEN, Wayne LIN, Hsueh-Yu LU, Chi-Yu LEE, Jung-Li TIEN and Yi-Hsin LAI Cretaceous fractionated I-type granitoids and metaluminous A-type granites in SE China: the Late Yanshanian post-orogenic magmatism	195
Carlos VILLASECA and Víctor HERREROS A sustained felsic magmatic system: the Hercynian granitic batholith of the Spanish Central System	207

CONTENTS

François BUSSY, Jean HERNANDEZ and Jürgen Von RAUMER Bimodal magmatism as a consequence of the post-collisional readjustment of the thickened Variscan continental lithosphere (Aiguilles Rouges-Mont Blanc Massifs, Western Alps)	221
Ulrike POLLER and Wolfgang TODT U-Pb single zircon data of granitoids from the High Tatra Mountains (Slovakia): implications for the geodynamic evolution	235
Jean-Pierre PUPIN Granite genesis related to geodynamics from Hf-Y in zircon	245
Philip PICCOLI, Philip CANDELA and Mark RIVERS Interpreting magmatic processes from accessory phases: titanite—a small-scale recorder of large-scale processes	257
L. J. ROBB, L. A. FREEMAN and R. A. ARMSTRONG Nature and longevity of hydrothermal fluid flow and mineralisation in granites of the Bushveld Complex, South Africa	269
C. Le CARLIER de VESLUD, M. CUNEY, J. J. ROYER, J. P. FLOC'H, L. AMÉGLIO, P. ALEXANDROV, J. L. VIGNERESSE, P. CHÈVREMONT and Y. ITARD	
Relationships between granitoids and mineral deposits: three-dimensional modelling of the Variscan Limousin Province (NW French Massif Central)	283
Sarah CARRUZZO, Daniel J. KONTAK, and D. Barrie CLARKE Granite-hosted mineral deposits of the New Ross area, South Mountain Batholith, Nova Scotia, Canada: P, T and X constraints of fluids using fluid inclusion thermometry and decrepitate analysis	303
AUTHOR INDEX	321

iv