

# The Eruption of Soufrière Hills Volcano, Montserrat from 2000 to 2010

The Geological Society of London  
**Books Editorial Committee**

**Chief Editor**

RICK LAW (USA)

**Society Books Editors**

JIM GRIFFITHS (UK)

DAVE HODGSON (UK)

HOWARD JOHNSON (UK)

PHIL LEAT (UK)

DANIELA SCHMIDT (UK)

RANDELL STEPHENSON (UK)

ROB STRACHAN (UK)

MARK WHITEMAN (UK)

**Society Books Advisors**

GHULAM BHAT (INDIA)

MARIE-FRANÇOISE BRUNET (FRANCE)

JAMES GOFF (AUSTRALIA)

MARIO PARISE (ITALY)

SATISH-KUMAR (JAPAN)

MARCO VECOLI (SAUDI ARABIA)

GONZALO VEIGA (ARGENTINA)

MAARTEN DE WIT (SOUTH AFRICA)

### **Geological Society books refereeing procedures**

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 Books Editorial 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 Book Editors 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 Book 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.

More information about submitting a proposal and producing a book for the Society can be found on its website: [www.geolsoc.org.uk](http://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:

WADGE, G., ROBERTSON, R. E. A. & VOIGHT, B. (eds) 2014. *The Eruption of Soufrière Hills Volcano, Montserrat from 2000 to 2010*. Geological Society, London, Memoirs, **39**.

ODBERT, H. M., STEWART, R. C. & WADGE, G. 2014. Cyclic phenomena at the Soufrière Hills Volcano, Montserrat. In: WADGE, G., ROBERTSON, R. & VOIGHT, B. (eds) *The Eruption of Soufrière Hills Volcano, Montserrat from 2000 to 2010*. Geological Society, London, Memoirs, **39**, 41–60, <http://dx.doi.org/10.1144/M39.2>

GEOLOGICAL SOCIETY MEMOIR NO. 39

The Eruption of Soufrière Hills Volcano,  
Montserrat from 2000 to 2010

EDITED BY

G. WADGE

University of Reading, UK

R. E. A. ROBERTSON

University of the West Indies, Trinidad and Tobago

and

B. VOIGHT

Pennsylvania State University, USA

2014

Published by

The Geological Society

London

## THE GEOLOGICAL SOCIETY

The Geological Society of London (GSL) was founded in 1807. It is the oldest national geological society in the world and the largest in Europe. It was incorporated under Royal Charter in 1825 and is Registered Charity 210161.

The Society is the UK national learned and professional society for geology with a worldwide Fellowship (FGS) of over 10 000. The Society has the power to confer Chartered status on suitably qualified Fellows, and about 2000 of the Fellowship carry the title (CGeol). Chartered Geologists may also obtain the equivalent European title, European Geologist (EurGeol). One fifth of the Society's fellowship resides outside the UK. To find out more about the Society, log on to [www.geolsoc.org.uk](http://www.geolsoc.org.uk).

**The Geological Society Publishing House** (Bath, UK) produces the Society's international journals and books, and acts as European distributor for selected publications of the American Association of Petroleum Geologists (AAPG), the Indonesian Petroleum Association (IPA), the Geological Society of America (GSA), the Society for Sedimentary Geology (SEPM) and the Geologists' Association (GA). Joint marketing agreements ensure that GSL Fellows may purchase these societies' publications at a discount. The Society's online bookshop (accessible from [www.geolsoc.org.uk](http://www.geolsoc.org.uk)) offers secure book purchasing with your credit or debit card.

To find out about joining the Society and benefiting from substantial discounts on publications of GSL and other societies worldwide, consult [www.geolsoc.org.uk](http://www.geolsoc.org.uk), or contact the Fellowship Department at: The Geological Society, Burlington House, Piccadilly, London W1J 0BG: Tel. + 44 (0)20 7434 9944; Fax + 44 (0)20 7439 8975; E-mail: [enquiries@geolsoc.org.uk](mailto:enquiries@geolsoc.org.uk).

For information about the Society's meetings, consult *Events* on [www.geolsoc.org.uk](http://www.geolsoc.org.uk). To find out more about the Society's Corporate Affiliates Scheme, write to [enquiries@geolsoc.org.uk](mailto:enquiries@geolsoc.org.uk).

Published by The Geological Society from:

The Geological Society Publishing House, Unit 7, Brassmill Enterprise Centre, Brassmill Lane, Bath BA1 3JN, UK

The Lyell Collection: [www.lyellcollection.org](http://www.lyellcollection.org)

Online bookshop: [www.geolsoc.org.uk/bookshop](http://www.geolsoc.org.uk/bookshop)

Orders: Tel. + 44 (0)1225 445046, Fax + 44 (0)1225 442836

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 2014. No reproduction, copy or transmission of all or part of this publication may be made without the prior written permission of the publisher. In the UK, users may clear copying permissions and make payment to The Copyright Licensing Agency Ltd, Saffron House, 6-10 Kirby Street, London EC1N 8TS UK, and in the USA to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, USA. Other countries may have a local reproduction rights agency for such payments. Full information on the Society's permissions policy can be found at: [www.geolsoc.org.uk/permissions](http://www.geolsoc.org.uk/permissions)

### **British Library Cataloguing in Publication Data**

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

ISBN 978-1-86239-630-2

ISSN 0435-4052

### **Distributors**

For details of international agents and distributors see:

[www.geolsoc.org.uk/agentsdistributors](http://www.geolsoc.org.uk/agentsdistributors)

Typeset by Techset Composition India (P) Ltd, Bangalore and Chennai, India

Printed by Berforts Information Press Ltd, Oxford, UK

## Preface

It would have seemed incredible to anyone on the streets of Plymouth, Montserrat on 18 July 1995, listening to the strange roaring sound occurring somewhere beyond Chance's Peak, to be told that this was the start of a volcanic eruption that would go on for over 15 years. The longevity of this eruption of Soufrière Hills Volcano has also taken experienced volcanologists by surprise. There had been no previous recorded eruptions on Montserrat in historical time and the longest known eruption in the whole Lesser Antilles island arc prior to this was the 3.5 year eruption of Mont Pelée, Martinique from 1902 to 1905. So this eruption is a rare beast. Less surprising is that the eruption has had such a profound effect on the people of Montserrat. The small size of the island coupled with this energetic eruption inevitably meant that the loss of infrastructure, housing and safe land to the volcano would result in hardship, emigration and changes to the Montserratian sense of community.

The story of these years of eruption have been told in many ways – as news, social observation, political polemic, picture books, poetry and, of course, scientific investigation. This volume is the latest in the latter category and follows directly from Memoir 21 of the Geological Society, London, which covered the first 5 years of the eruption from 1995 to 1999. This volume covers the 11 years of the eruption from 2000 to 2010, specifically up to the extrusion of lava last observed on 10 February 2010 and ended by a collapse of the volcano's dome to the north.

Whilst this volume is a chronological continuation of Memoir 21, it differs from it in several ways. The observations and insights from the geochronology of the island, dome growth, dome collapse, multiple styles of pyroclastic density current generation, repetitive Vulcanian explosions and fallout, and cyclic near-field deformation that dominated

the earlier memoir are built upon here, but the emphasis is shifted to different phenomena and methods: surge generation, multiple cycles of activity, island-wide geodetic measurements, seismic tomography of magma reservoirs and a clearer view of the evolution of the magma mingling processes. Also there are two papers on social science applications to Montserrat volcanology, reflecting the enhanced interest in this approach over the past decade. This period also happens to have seen the establishment of two of the main pillars of Montserrat volcanology: the (custom-built) Montserrat Volcano Observatory (MVO) at Flemmings, and the Scientific Advisory Committee on Montserrat Volcanic Activity (SAC) of the UK Foreign and Commonwealth Office. The physical and institutional stability brought by the MVO and the SAC since 2002 has led to a more confident basis for the science described herein, both in terms of long-term repositories of experience and expertise, and a well-run base for experiments.

So far there have been five phases of lava extrusion and five intervening pauses between 1995 and 2013. The current pause (February 2010–2013) is the longest so far and it could represent the end of the current eruption (for many years). However, on-going GPS (global positioning system)-measured inflation and the relatively high levels of sulphur dioxide emission, as measured also in previous pauses in extrusion, suggest that the deep system below the volcano is still active and lava extrusion may resume. Deciphering such signals in terms of long-term behaviour is an active research topic yet to be solved. One thing is clear, as exemplified by the science in this Memoir, even with just the data collected so far from this quite remarkable volcano, there is still much more to learn, use and marvel at.

## Acknowledgements

Hundreds of scientists and students have been involved in work on the Soufrière Hills Volcano since 2000 and a comprehensive list is beyond us. Almost all of those people have passed through the Montserrat Volcano Observatory and made use of their facilities, and the observatory staff (catalysts for so much of this work) deserve to be acknowledged. The MVO Directors over this period were: Simon Young, Gill Norton, Peter Dunkley, Ricky Herd, Sue Loughlin, Vicky Hards, Mick Strutt, Richard Robertson, Nico Fournier, Jean-Christophe Komorowski, Paul Cole and Roderick Stewart. MVO staff were: Venus Bass, Racquel Syers, Dave Williams, Pyiko Williams, Marie Edmonds, Ricky Herd, Lizette Rodriguez, Glenn Thompson, Art Jolly, Graham Ryan, Lars Ottemöller, Richard Luckett, Lee Jones, Aoife O'Monoghain, Raamkanna Saranathan, Machel Higgins, Thomas Christopher, Brian Baptie, Lorraine Ruzié, Silvio De Angelis, Marlon Fergus, G. Levieux, Frederic Dondin, A. Finizola, Erouscilla Joseph, Y. Legendre, V. Clouard, L. Babal, L. Chardot, H. Odbert, R. Simpson, P. Smith, J. Stone, B. Tsaines, C. Eligon, L. Gunn, Adam Stinton, Rob Watts, Caroline Murrell and Karen Pascal (sorry to any we have missed).

We would like to thank Angharad Hills and Tamzin Anderson of the Geological Society Publishing House for their help in bringing this volume to fruition, and all of the authors for their patience. We are particularly grateful for all our reviewers' efforts in getting the papers fit for your reading: Ben Andrews, Daniele Andronico, Willy Aspinall, Jenni Barclay, Jon Blundy, Katharine Bull, Daniele Carbone, Maria Charco, Gail Christesen, Michael Clyne, Shane Cronin, Paul Cullinan, Silvio

de Angelis, Pierre Delmelle, Tim Druitt, Jean-Christophe Gaillard, Kat Haynes, Stefi Hautmann, Richard Herd, Madeleine Humphreys, Jeff Johnson, Art Jolly, Gill Jolly, Peter Kokelaar, Jean-Christophe Komorowski, Steve Lane, Phil Leat, Mario Mattia, Henry Odbert, Domenico Patane, Matt Patrick, Michel Pichavant, Virginie Pinel, Mike Poland, Steve Self, Bruno Scaillet, Hiroshi Shinohara, Alan Smith, Stephen Sparks, Bruce Sutherland, Rob Watts, Andy Woods and G. Zellmer.

The provision of colour printing throughout the Memoir was enabled by the generosity of the Seismic Research Centre of the University of the West Indies.

Not least, our thanks go also to the good people of Montserrat, who have allowed us the use of their properties for instrument deployment, and who assisted our scientific work in innumerable ways since the eruption began. They have borne many hardships with courage, good nature and dignity.

Joe Devine died on 28 July 2013, before he could submit a second manuscript for this volume. Joe was a first-rate scientist and key figure in advancing petrological understanding of the Soufrière Hills eruption. In particular, he will be remembered for his work on hornblende rims as a proxy for magma rise rate and for his operational evaluation of newly erupted ash samples on MVO's behalf.

G. Wadge, R. E. A. Robertson & B. Voight  
(Editors)