Environmental Geochemistry and Health
with special reference to developing countries

Geological Society Special Publications
Series Editor A. J. FLEET

GEOLOGICAL SOCIETY SPECIAL PUBLICATION NO. 113

Environmental Geochemistry and Health

with special reference to developing countries

EDITED BY

J. D. APPLETON
British Geological Survey
Nottingham, UK

R. FUGE
Institute of Earth Studies
University of Wales
Aberystwyth, UK

and

G. J. H. McCALL
Department of Earth Studies
Liverpool University, UK

1996
Published by
The Geological Society
London

THE GEOLOGICAL SOCIETY

The Society was founded in 1807 as The Geological Society of London 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'. The Society is Britain's national society for geology with a membership of around 8000. It has countrywide coverage and approximately 1000 members reside overseas. The Society is responsible for all aspects of the geological sciences including professional matters. The Society has its own publishing house, which produces the Society's international journals, books and maps, and which acts as the European distributor for publications of the American Association of Petroleum Geologists, SEPM and the Geological Society of America.

Fellowship is open to those holding a recognized honours degree in geology or cognate subject and who have at least two years' relevant postgraduate experience, or who have not less than six years' relevant experience in geology or a cognate subject. A Fellow who has not less than five years' relevant postgraduate experience in the practice of geology may apply for validation and, subject to approval, may be able to use the designatory letters C Geol (Chartered Geologist).

Further information about the Society is available from the Membership Manager, The Geological Society, Burlington House, Piccadilly, London W1V 0JU, UK. The Society is a Registered Charity, No. 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. 01225 445046
Fax 01225 442836)

First published 1996

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

ISBN 1-897799-64-0
ISSN 0305-8719

Typeset by Bath Typesetting, Bath, UK

Printed by The Alden Press, Osney Mead, Oxford, UK

Distributors

USA
AAPG Bookstore
PO Box 979
Tulsa
OK 74101-0979
USA
(*Orders:* Tel. (918) 584-2555
Fax (918) 584-2652)

Australia
Australian Mineral Foundation
63 Conyngham Street
Glenside
South Australia 5065
Australia
(*Orders:* Tel. (08) 379-0444
Fax (08) 379-4634)

India
Affiliated East-West Press PVT Ltd
G-1/16 Ansari Road
New Delhi 110 002
India
(*Orders:* Tel. (11) 327-9113
Fax (11) 326-0538)

Japan
Kanda Book Trading Co.
Tanikawa Building
3-2 Kanda Surugadai
Chiyoda-Ku
Tokyo 101
Japan
(*Orders:* Tel. (03) 3255-3497
Fax (03) 3255-3495)

Contents

Preface

Environmental geochemistry has long been known to influence human and animal health, the links being recognized possibly as long ago as the 4th century AD by the Chinese. While early recognized problems such as endemic goitre were clearly due to natural geochemical variations within the environment, more recently anthropogenic perturbations of the environment have been shown to exert a strong influence on human and animal well being.

Although some health problems related to environmental geochemistry manifest themselves in the developed world, they are more keenly felt in the developing countries due to the added stress of such factors as poverty and malnutrition. In addition, while most of the population of the developed world have diets which include food sources from geographically diverse regions, in the developing countries this is frequently not so. Many people in developing countries are dependent on very localized sources of food and water and any geochemical anomaly (enrichment or depletion) within these local environments will have a marked influence on the well-being of the inhabitants.

The latest World Health Organisation figures indicate that more than 800 million people in the developing countries are at risk from iodine deficiency, which is the cause of goitre and cretinism, a severe form of mental retardation. 350 million people in developing countries are estimated to suffer from severe iron deficiency and recent studies have provided evidence that cancer and heart disease are related to selenium deficiencies. High natural environmental concentrations of fluorine cause mottling of teeth and crippling bone and joint deformities in both humans and cattle. Excessive dietary intakes of aluminium, arsenic and lead derived from both natural sources and as a result of industrial pollution are also associated with ill-health in humans. Concern over this issue is increasing as a result of rapid economic and population growth in the developing world. Multidisciplinary studies involving epidemiologists and biochemists as well as environmental and nutritional specialists are essential if the impact of trace element levels on ill-health in developing countries is to be properly addressed and remedies implemented.

The main aim of this volume is to discuss the application of geochemistry to the study of human and animal health problems in developing countries. It stems from a conference held at the Geological Society, Burlington House, London, UK on 20–21 October 1993 which was organized by the Joint Association of Geoscientists for International Development (JAGID) and the Society for Environmental Geochemistry and Health (SEGH). The conference provided a forum for the exchange of ideas, information and experience between geochemists, nutritionists, medical and veterinary researchers and brought together researchers from UK, Poland and Sweden as well as a range of developing countries including India, Kenya, Tanzania, Uganda and Sri Lanka. Of the 34 papers presented at the meeting, 20 are published in this volume while two invited contributions have been added. Abstracts of the other 14 papers are published in *Environmental Geochemistry and Health in Developing Countries, October 1993: Abstracts Volume*. This is available (price code I) from BGS Publications (Tel: 0115 936 3241).

Subjects covered in the volume reflect the breadth of the topic under discussion, ranging through animal and human health issues related to soil, plant, water and

volcanic gas chemistry. The role of natural and anthropogenic influences on the environment are covered as are the roles of geochemical mapping, monitoring and baseline identification.

The first two papers in the volume set the scene, with considerations of the aetiology of geochemically related nutritional diseases (**Mills**) and the role of geochemistry in environmental and epidemiological studies in developing countries (**Plant *et al.***). The next group of five papers concern animal nutrition in Zimbabwe (**Fordyce *et al.***), Kenya (**Jumba *et al*; Maskall & Thornton**) and the Kenya–Uganda border area (**Bowell *et al.***). Finally in this section **Selinus *et al.*** present a Swedish view of environmental monitoring using aquatic mosses, roots of aquatic plants and organ tissues from the moose.

Health aspects of groundwater chemistry are reviewed by **Edmunds & Smedley** followed by contributions on biogeochemical factors affecting groundwater quality in Tanzania (**Bowell *et al.***), water quality and dental fluorine in Sri Lanka (**Dissanayake**), and the geochemistry of aluminium and its potential toxicity in Uganda (**Smith *et al.***). The environmental behaviour of arsenic is reviewed by **Thornton**, while **Smedley *et al.*** consider the health implications of this element in groundwater in a gold-mining area in Ghana. The population theme is continued with a consideration of the impacts of mining and smelting on the Polish environment (**Helios Rybicka**) and on the use of lake sediments to assess mining and urban contamination in Papua New Guinea (**Nicholson**).

Iodine with its long recognized link to health is the subject of three papers, beginning with a consideration of its geochemistry (**Fuge**). Papers on the aetiology of endemic goitre in Sri Lanka (**Dissanayake & Chandrajith**) and on the epidemiology of iodine deficiency disorders (**Stewart & Pharoah**) consider the role of iodine and other factors in these diseases.

The role of trace elements in preventing aflatoxin induced cell damage and disease and the potential influence of geographical variations in trace element levels on disease patterns is discussed by **Nair *et al.*** **Nicholson *et al.*** consider the negative environmental impacts of acidic volcanic gas emissions in Costa Rica on crops, buildings and the health of domestic livestock and people. The penultimate paper demonstrates how a geostatistical method (kriging) can be used to investigate the links between the geographical distribution of disease and environmental factors (**Oliver**), while the final paper is a review of geochemical factors which may influence the distribution of Podoconiosis, or non-filarial elephantiasis, in tropical Africa (**Harvey *et al.***).

The editors are particularly grateful to JAGID, SEGH, the British Council (Kenya) and the Overseas Development Administration who provided support which facilitated the attendance of some of the participants from developing countries. We wish to express our thanks to the authors for their patience and collaboration and to the many reviewers whose suggestions and comments helped to ensure that the papers published here maintain the consistently high standards of Geological Society Special Publications. The considerable efforts of the production editor, David Ogden, and other staff at the Geological Society Publishing House, Bath, are much appreciated.

Don Appleton
Ron Fuge
Joe McCall

March 1996