The Medical Geology revolution—The evolution of an IUGS initiative

Introduction

In December 2003 *Episodes* published an article entitled "Medical Geology: New Relevance in the Earth Sciences" by Bowman, Bobrowski, and Selinus. This paper was just one early example of the interest and excitement sparked by this emerging field of medical geology—the impacts of geologic materials and geologic processes on animal and human health. Medical geology attempts to bring together geoscientists and biomedical/public health researchers to address a range of environmental health problems. Much of the impetus for the resurgence of interest in medical geology was a direct result of support and encouragement from the International Union of Geological Sciences (IUGS) and its former Commission on Geologic Sciences for Environmental Planning (COGEOENVIRONMENT). This manuscript will review the recent evolution of medical geology, from its initial insertion as a COGEOENVIRONMENT Working Group to its current status as a global Association with thousands of proponents worldwide. We will also briefly speculate about the future of this exciting new field stimulated by the IUGS.

A brief history

Although geologic factors play key roles in a range of environmental health issues that impact the health and well-being of billions of people worldwide (Bowman et al., 2003), there is a general lack of understanding of the importance of these factors on animal and human health amongst the general public, the biomedical/public health community, and even within the geoscience community. The limited extent of interdisciplinary cooperation and communication among these areas has restricted the ability of scientists and public health workers to solve a range of complex environmental health problems. In response to this situation, in 1996 the IUGS commission COGEOENVIRONMENT established an International Working Group on Medical Geology led by Olle Selinus of the Geological Survey of Sweden (SGU). The primary aim of the Medical Geology Working Group was to increase the awareness of this issue among geoscientists, medical specialists, and the general public.

Since the establishment of the COGEOENVIRONMENT Working Group on Medical Geology in 1996 there has been rapid development of this field. In October 1997 the Working Group met in Vale, Colorado, USA during the Fourth International Symposium on Environmental Geochemistry. At this meeting the term "Medical Geology" was adopted by the participants as a descriptor of this environmental health subdiscipline. The next meeting of the Working Group took the form of a workshop in Uppsala, Sweden in 1998. Discussions focused on the feasibility of preparing a new textbook on medical geology. In September 2000, about 50 people participated in a meeting and workshop again in Uppsala. A two-day seminar was held on medical geology "The Geochemical Environment and Human Health" resulting in a proceedings volume (Skinner and Berger, 2002). The workshop participants discussed the future work of the group, newsletters, an internet home page, generating other informational material, and publishing an interdisciplinary book on medical geology for a broad multidiciplinary audience.

In 2000, the International Geologic Correlations Programme (IGCP) established a new project "IGCP 454 Medical Geology". IGCP projects are jointly sponsored by UNESCO (United Nations Education, Scientific and Cultural Organization) and IUGS. The IGCP 454 project was chaired by Olle Selinus with co-chairs Peter Bobrowsky (Canada) and Ed Derbyshire (UK). The primary aim of the IGCP project was to bring together scientists in developing countries working on medical geology issues with their colleagues in other parts of the world. The project focused on capacity building, providing training as well as exchange of information, research and laboratory experiences. This initiative provided, for the first time, the opportunity for scientists (geoscientists, physicians, geographers, veterinarians, etc.) from developed and developing countries to come together in a truly international and inter-disciplinary forum and to identify and tackle significant environmental health problems.

In 2000, Bob Finkelman, a geoscientist then with the U.S. Geological Survey (USGS) and Jose Centeno, a chemical toxicologist with the U.S. Armed Forces Institute of Pathology (AFIP) joined the COGEOENVIRONMENT Working Group and the IGCP 454 project. Since 1996 Jose and Bob had been working independently on medical geology on issues that parallelled and complemented the objectives of the IUGS supported activities. Their work on arsenic (Centeno et al., 2002 a and b, Tchounwou et al., 2003, and fluorine poisoning from residential coal combustion (Belkin et al., 1977 and 2003, Wang et al., 2004), in China and Balkan Endemic Nephropathy (Feder et al., 1991, Orem et al., 1999, Tatu et al., 1998) had attracted much positive attention (Finkelman et al., 2001 and a note in the February, 2002 issue of Scientific America). Moreover, Bob and Jose had developed a popular short course on the health impacts of trace elements and metal ions that was easily modified to suit the objectives of the IUGS Medical Geology Working Group.

Bob Finkelman and Jose Centeno presented a one-day short course at the 2001 COGEOENVIRONMENT meeting in Lusaka, Zambia followed by a one-day session at the nearby University of Zambia. The excitement generated at both venues was a convincing demonstration that the medical geology short course would be a powerful tool with which to advance the objectives of the IUGS Working Group. A proposal was then developed to bring this short course to developing countries having critical medical geology problems. The proposal was submitted to the International Commission on Scientific Unions (ICSU) providing a $50,000 grant to support a small number of medical geology short courses for 2002–2003. This was the first ICSU grant awarded for any IUGS activitity.

As a result of its significant achievements, the COGEOENVIRONMENT Working Group on Medical Geology was given Special Project status in March 2002 to operate directly under the IUGS.

Medical geology short courses—spreading the message

With the support of IUGS, COGEOENVIRONMENT, USGS, AFIP, SGU, and the host countries, the ICSU money was used to fund many more short courses than had been proposed. (Figures 1,2) These courses led by Jose Centeno, Bob Finkelman and Olle Selinus have been presented at 32 occasions all over the world (see list below) and have been attended by more than two thousand students and professionals with backgrounds in geoscience, biomedical/public health science, enviromental science, geography, engineering, chemistry, etc. As part of the scientific program for these short courses local scientists are invited to describe medical geology work going on in their regions and in some courses students were encouraged to present their work as posters.

Figure 1 Short course in Brazil.

Figure 2 Short course in Egypt.

The aim of the short courses is to share the most recent information on the relationship between toxic metal ions, trace elements, minerals, etc. and their impact on the environmental and public health issues. The scientific topics of the course include environmental toxicology, environmental pathology, geochemistry, geoenvironmental epidemiology, extent, patterns and consequences of exposures to toxic metal ions, and analysis of geologic and biologic materials.

The courses, generally 2 to 3 days in length, are intended for anyone interested in the effects of natural materials and natural geological events on animal and human health. An important objective of the courses is to provide an opportunity for forming contacts and networks between professionals working in different countries and on different aspects of environmental health issues. We have produced a 300 page syllabus and a CD containing the lecture materials used in the short course as well as supplementary material such as reprints of relevant articles for participants to use in their regions and on their respective disciplines. The use of the course material by participants to conduct their own regional courses in medical geology is highly encouraged. (Figure 3).

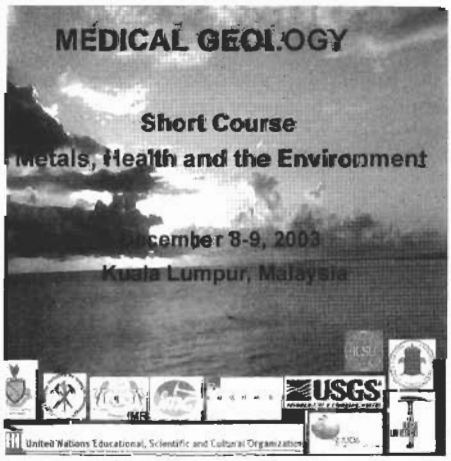

Figure 3 Frontpage of a short course syllabus CD.

The following short courses have been carried out partially or fully funded by the IUGS and the ICSU grant:

Year	Countries
2001	Zambia, South Africa
2002	Chile, Russia, Peru, Japan, China
2003	Lithuania, Great Britain, Uruguay, Brazil, Australia, Malaysia
2004	South Africa, Mozambique, Hungary, Canada, Australia, India
2005	Romania, Brazil, Uruguay, Argentina, USA, Ireland, Puerto Rico, Turkey, Egypt, Sweden.
2006	Portugal, USA, China,
2007	Mexico, Brazil
Requests for courses	Jamaica, Kenya, Norway, Taiwan, Nigeria, Ghana, Pakistan, India, Spain, Russia, Poland, Thailand, Iraq, Iran, Israel, Indonesia, Mexico, Trinidad & Tobago, Haiti, Cyprus, England, Turkey, Bangladesh,

Medical Geology—A global affair

One of the first activities of the IUGS Medical Geology Working Group was to establish and maintain communications with an audience dispersed throughout the world, many scientists in developing countries with limited access to communication capabilities. The Working Group established a Medical Geology web site (*http://www.medicalgeology.org*). This website is regularly updated and is a key source of information on the subject. The Working Group also produces a newsletter twice a year edited by Dave Elliott, from Canada. The newsletter is distributed to all members of the working group. Currently, all issues of the newsletter can be accessed by visiting the Medical Geology web site.

Nearly 1,000 people signed up as corresponding members of the Medical Geology Working Group from more than 90 countries around the globe.

Publications

Information and news on the working group has been published in different journals. The November, 2001 issue of *Geotimes* featured the growing area of Geosciences and Human Health and contained several articles authored by members of the IUGS Medical Geology Working Group (Finkelman et al 2001).

Several papers and special journal issues have also been published, drawing national and international attention to medical geology. Some key examples of these publications are:

- "Environmental Medicine," a book published in 2000 at the Karolinska Institute, Uppsala, Sweden. One chapter is on Medical Geology. This book is now used for courses for medical students at the Karolinska Institute and elsewhere (Selinus, Frank 1999).
- A paper was published in 1999 on medical geology in tropical countries (Dissanayake, Chandrajith 1999).
- A new book "Geoenvironmental Mapping" (edited by P. Bobrowsky) was published in 2001. One chapter is on Medical Geology (Selinus 2002).
- The BGS magazine, Earthwise, has published a thematic issue on Geology and Health (Earthwise 2001).
- "Epidemioecology News" (now called GeoHealth News), a new newsletter on medical geology is published by USGS.
- A book, *Geology to Health*, published by Oxford University Press, covered all the presentations given at the meeting in Uppsala in 2000 (Skinner, Berger 2000).
- A first special issue of *Environmental Geochemistry and Health* devoted to medical geology activities in developing countries has been published (Vol. 29, No.2) and a second special issue is in preparation.
- Special issue of the journal AMBIO (Volume 36(1), February 2007) published a series of papers on medical geology.
- Special issue of BRGM Geosciences, vol 5 (March 2007), dedicated to geosciences and health published a series or papers on medical geology
- For additional publications of the IUGS Medical Geology Working Group see the reference list at the end of this article. (Berger et al 2001, Bunnell 2004, Ceruti et

al 2001, Dissanayake 2004, Kinniburgh, Smedley 2001, Kousa et al 2004, Selinus 2004).

For the first time there was a paper on medical geology in Scientific American. This was published in February 2002, covering health effects of coal burning. Bob Finkelman was active in this.

Recently, two books on Medical Geology have been published, one from India (Workshop on Medical Geology, 2004) and the other from Brazil (Roberto da Silva et al., 2006). They are based on medical geology meetings in these countries and cover all aspects of medical geology in South America and the Indian subcontinent.

Symposia and congresses

The working group and IGCP project has been involved in promoting medical geology at meetings around the world by organizing and/or sponsoring special sessions or symposia on medical geology. The working group has also provided financial support for students and professionals from developing countries to participate in scientific and public health events.

The following list contains a few selected examples of the sponsored symposia. (For a complete list see the Medical Geology web site at *http://www.medicalgeology.org*):

- 2000 The International Geological Congress, Rio de Janeiro. A symposium on Geoscience and Health was organized in conjunction with the main congress. We also held a meeting of the Working Group and IGCP 454.
- 2001 Second East and Southern Africa Regional Workshop in Geomedicine, Lusaka, Zambia.
- 2001 Geological Society of America, Boston, Pardee Symposium on "The Emerging Discipline of Medical Geology".
- 2002 The Pacific Basin Conference on Hazardous Waste, Manila, Philippines.
- 2002 Washington DC: Healthy Ecosystems—Healthy people, Linkages between biodiversity, ecosystem health and human health was organized in collaboration with the National Academy of Sciences.
- 2002 we presented the project at the XXIV International Congress of the International Academy of Pathology. A special symposium on environmental pathology/medical geology was organized. This was a very important meeting since this was the first time medical geology had been presented for this large audience of medical and health professionals.
- 2002 FOREGS meeting in Helsinki. This was a general assembly meeting for all director generals for all geological surveys in Europe (about 40 countries presented). Medical Geology was introduced and dissussed among this group of director generals.
- 2002 Quebec, ISTERH, International Society for Trace Elements in Humans.
- 2002 1st international symposium on geopollution and medical geology, Tokyo, Japan.
- 2002 we received a special invitation from the Royal Norwegian Academy of Sciences to present a lecture on medical geology.
- 2002 GSA symposium on Human Health Science & Geoscience: Bridging the Gap, Boston.
- 2003 Ankara, Turkey, Congress on Medical Geology and Cancer.
- 2003 The U.S. Geological Survey hosted a conference entitled "Natural Science and Public Health—Prescription for a Better Environment Co-sponsored by the Armed Forces Institute of Pathology, the U.S. Environmental Protection Agency, and The George Washington University's School of Public Health.
- 2003 A special symposium on medical geology was organised at the 7th International conference on biogeochemistry of trace metals, in Sweden.
- 2003 In Edinburgh, at the Sixth International Symposium on Environmental Geochemistry, there was an official meeting, a short course and special sessions on medical geology.
- 2003 Chilean Geological congress—Medical Geology Symposium.
- 2004 The sixth International Conference on Arsenic Exposure and Health Effects, San Diego, USA.
- 2004 XXV Congress of the International Academy of Pathology, Brisbane, Australia.
- First Hemispheric Conference on Medical Geology, University of Turabo in Gurabo, Puerto Rico.
- 2005 20th European Congress of Pathology, Paris.
- 2006 3rd International Conference on Metals in the Environment in Vilnius, Lithuania.
- 2006 International Symposium on Medical Geology in Stockholm, Royal Swedish Academy of Sciences.
- 2006 43rd Brazilian Geological Congress
- 2006 7th International Symposium on Environmental Geochemistry (ISEG).

In addition, Working Group members have been invited to talk about Medical Geology at numerous universities, colleges, research hospitals, science clubs, etc. in more than 30 countries.

Medical geology—global impacts

The activities of the IUGS Medical Geology Working Group has had, and will continue to have, profound impacts around the world. The following items are just some of the outcomes from this initiative.

UN Year of Planet Earth

The International Year will be proclaimed through the United Nations, and has been adopted by the UNESCO Division of Earth Sciences as one of its core activities.

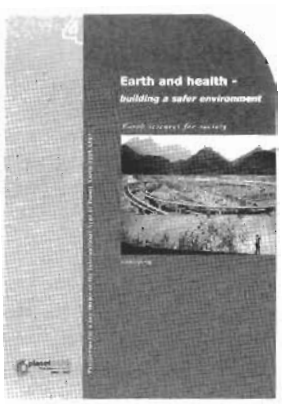

Figure 4 Earth and Health, one of the topics of International Year of Planet Earth.

The aim of the International Year of Planet Earth is to demonstrate new and exciting ways in which Earth sciences can help future generations meet the challenges involved in ensuring a safer and more prosperous world (www.yearofplanetearth.org).

The achievement of this aim will be supported by two major programmes.

- Outreach Programme including educational ventures at all levels.
- Science Programme concentrating on 'big issues' of complex interaction within the Earth system, and its long-term sustainability.

The initiative will seek to raise the awareness of the contribution to, and role of the Earth sciences in society in the minds of politicians, decision-makers, the media and the general public. One of the topics will be "Earth and Health", that is medical geology (Figure 4).

Interdisciplinary Book on Medical Geology

A book on Medical Geology has been published by Elsevier (Academic Press) in 2005 (Selinus et al 2005). O. Selinus is chief editor and there are 6 associate editors: Brian Alloway, Jose Centeno and Bob Finkelman, Ron Fuge, Ulf Lindh, and Pauline Smedley. There are almost 60 distinguished authors from all around the world. About 50% are geoscientists and about 50% are medics, veterinarians and other scientists. The book contains more than 800 pages with illustrations in full colour. The audience of the book will be junior to senior undergraduates and educated decision-makers. The main objective is to emphasise the importance of geology in health and disease in humans and animals (Figure 5).

Essentials of Medical Geology was in November 2005 recognized as a "Highly Commended" title in the Public Health category by the British Medical Association. As many likely know, this is a very prestigious acknowledgment. The book is one of the best of all published books in Public Health in 2005. They bestow awards upon publications "which are deemed to best fulfill the criteria of clinical accuracy and currency and which

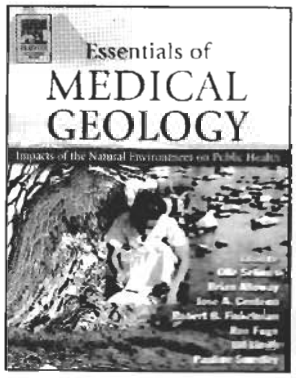

Figure 5 Essentials of Medical Geology.

maintain a high standard of design and production".

Essentials of Medical Geology also won a second prestigious award in January 2006.

It was one of two winners in the "Geology Geography" category of the 2005 Awards for Excellence in Professional and Scholarly Publishing. The PSP awards recognize both editorial standards as well as design and production standards. PSP is the Professional Scholar Publishing division of the Association of American Publishers. The book has now thus been recognized in both communities for which it was intended (first by the British Medical Association, and then as a Geology resource).

A third award by Choice was won in 2007. Every year Choice publishes a list of Outstanding Academic Titles that were reviewed during the previous calendar year. This prestigious list reflects the best in scholarly titles reviewed by Choice and brings with it the extraordinary recognition of the academic library community. The list was known as Outstanding Academic Books until 2000.

Medical Geology Registry

The Armed Forces Institute of Pathology (AFIP), Washington DC, USA has established a registry on medical geology. The Registry on Medical Geology serves as the liaison between the medical/pathology community and the earth sciences, environmental and public health professionals. The aims of the Registry on Medical Geology are:

1. to facilitate the interactions between the medical/public health community and the earth sciences, toxicologists, and other related areas;
2. to provide a centralized facility for the sharing of information, materials and research projects on medical geology;
3. to provide opportunities for training (i.e., postdoctoral, postmedical, visiting scientist/professor, etc.) on medical research with particular emphasis on medical geology, environmental and environmental epidemiology research; and
4. to develop educational materials, publications and activities (courses, workshops, symposia, conference) on medical geology research topics.

The Medical Geology Registry supports the International Medical Geology Association by providing information on environmental risk factors including dust composition, toxic elements, and background data. The studies conducted at this Registry use the capabilities of the AFIP on archival, identification, and relevant pathological, toxicological and epidemiological information.

The National Museum of Health and Medicine in Washington, DC, has also unveiled an exhibit highlighting the developing science of medical geology used by its parent organization, the AFIP, to study health problems associated with arsenic. The exhibit will run indefinitely.

U.S. National Research Council on "Earth Materials and Health"

A key report entitled "Earth Materials and Health—Research Priorities for Earth Sciences and Public Health" was recently released by the U.S. National Research Council (NRC). Working in closed collaboration with several environmental, public health and geosciences organizations, the US NRC was asked to undertake a study to explore avenues for interdisciplinary research that would further knowledge at the interface between the earth sciences and public health disciplines (i.e., medical geology). To fulfill this task, the NRC set up a study committee composed of geoscientists, toxicologists, epidemiologists, and public health professionals. The committee was charged with the task of advising on the high priority research activities that should be undertaken for optimum societal benefit, describing the most profitable areas of communication and collaboration between the earth sciences and public health communities. On its final report, the NRC study committee was asked to:

- Describe the present state of knowledge in the emerging field of medical geology.
- Describe the connections between earth science and public health, addressing both positive and negative societal impacts over the full range from large-scale interactions to micro-scale biogeochemical processes.
- Evaluate the need for specific support for medical geology research,and identify any basic research needs in bioscience and geoscience required to support medical geology research.
- Identify mechanisms for enhanced collaboration between the earth science and medical/public health communities.
- Suggest how future efforts should be directed to anticipate and respond to public health needs and threats, particularly as a consequence of environmental change.

New Division For Geology and Health at the Geological Society of America

At the Fall, 2004 annual meeting of the Geological Society of America (GSA), the GSA's Board of Directors approved the creation of a new Division dedicated to medical geology. More than 100 people signed the petition requesting the creation of the Geology and Health Divison. The Division's activities were evident at the 2006 GSA annual meeting where it sponsored or co-sponsored six symposia and technical sessions.

Medical geology is an exciting interdisciplinary field that, thanks to the critical support of the IUGS will continue to grow rapidly. Several geological surveys are integrating medical geology in their work and medical geology materials is now included in university courses and research for medical and public health students. In the future it will be important to improve communication among the various disciplines concerned with diseases caused by geological factors which influence the well being of humans and animals. To advance interdisciplinary research at the interface of public health and environment health, it is important to facilitate the formation of a consortium of government, industry and academia working together towards the creation of funding opportrunities in medical geology. Geological surveys, universities and geological societies should take a more active role in providing useful information on geologic conditions in medical geology and encourage the development of local working groups of multi-disciplinary medical geology experts. It would also be useful to encourage research in the area of producing more effective methodologies for the study of geological factors in environmental medicine and formulate recommendations for mitigation of effects of natural and man-induced hazardous geochemical conditions. Finally, for medical geology to be widely accepted, it is also of extreme importance to develop public outreach programs, conferences, and technical exhibitions aimed at enhancing community involvement and dialogue, improving risk communication concepts to better inform the public about ways to proactively prevent public health crises.

Figure 6 International Medical Geology Association, IMGA.

International Medical Geology Association (IMGA)

Our organisation has now reached the stage of development in which a formal structure is necessary for it to function efficiently (Finkelman et al 2004). As a result of the work to date, an International Medical Geology Association was launched in January 2006 (Figure 6). The structure will enable us to better respond to the opportunities, to rapidly pass information to those interested in Medical Geology issues, and to make critical decisions that will benefit the discipline. The name adopted for this new Association is "International Medical Geology Association" (IMGA). The Directors of the association are: Olle Selinus (Geochemist, Sweden) Bob Finkelman (Geologist, USA), and Jose Centeno (Biomedical research scientist, USA). David Elliott continues his work as editor of the Newsletter. Secretary is Kimberley Chisholm in Australia and treasurer is David Slaney in New Zealand. We have appointed six Councillors to represent the broad geographic distribution of Medical Geology and the wide range of disciplines that are embraced by this topic. The Councillors are: Bernardino Ribeiro de Figueiredo (Geologist, Brazil), Fiona Fordyce (Geochemist, UK), Zheng Baoshan (Geochemist, China), Calin Tatu (Medical researcher, Romania), Nomathemba Ndiweni (Veterinary Biochemistry, Zimbabwe), and Philip Weinstein (Epidemiologist, Australia) .

The association will be the umbrella for regional divisions around the world. These divisions include South America, Sub Sahara Africa, Indian subcontinent, two subdivisions covering South-East Asia and China, Australia, Oceania, Russia and NIS, North America, Europe, Southern Mediterranean and Central America and Caribbean Basin.

The future

It is always risky to anticipate what the future holds. Nevertheless, we are confident that the future for medical geology still looks promising, notwithstanding the already rapid growth of the sub-discipline. The book, *Essentials of Medical Geology*, has received an overwhelmingly positive response. This award winning book will remain as the primary source of information on the subject, being translated now into Chinese. The reviews have been uniformly positive and the first printing has nearly sold out in less than a year. We anticipate that the book will stimulate the teaching and research practice of medical geology in colleges and universities. The medical geology short course will continue to attract enthusiastic adherents and practioners of medical geology. The International Medical Geology Association will continue to provide a stable platform for the exchange of ideas and dissemination of information. The raft of other medical geology activities enumerated above will continue to stimulate enthusiasm and momentum for the next few years. After that medical geologists will have to demonstrate that what we have to offer will indeed benefit society by helping to improve the quality of life for people around the world.

Most importantly, the Medical Geology revolution illustrates the foresight and importance of the IUGS. By recognizing the need for this subdicipline and by providing critical financial and moral support during its formative years, the IUGS helped to foster this revolution and to contribute to its evolution.

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