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Profiles

Medical Geology: Emerging Discipline on the Ecosystem–Human Health Interface

Joseph E. Bunnell

U.S. Geological Survey, U.S. Department of the Interior, 956 National Center, Reston, VA 20192

Abstract: Medical geology is an emerging discipline that, broadly defined, examines the public health impacts of geologic materials and geologic processes. The scope and range of medical geology include: (1) identifying and characterizing natural and anthropogenic sources of harmful materials in the environment; (2) learning how to predict the movement and alteration of chemical, infectious, and other disease-causing agents over time and space; and (3) understanding how people are exposed to such materials and what can be done to minimize or prevent such exposure. Participants of a Medical Geology Working Group that met recently in Washington, DC, identified lessons learned to date in the development of this new field, noted research gaps that should be addressed, and recommended key priorities and directions for a sustainable future for medical geology.

Key words: medical geology, environmental health, ecosystem health, multidisciplinary, interdisciplinary, transdisciplinary

Introduction

While the juxtaposition of the terms may be new, medical geology is really a re-emerging field. Thousands of years ago, Hippocrates and Aristotle noted relationships between environmental factors and the distribution of various diseases. In ancient China and India, minerals were understood to have healing as well as potentially deleterious properties. But the 20th century celebrated reductionist science, and now the term "medical geology" strikes many as novel. The emergence of this field is evidenced by several recent articles, symposia, short courses, and workshops devoted to this scientific specialty. This article will highlight one such workshop, reveal the kinds of discussions that go on among practitioners of a field still in its formative stages, and present some of the many indications that medical geology is gaining recognition and building momentum.

What Is "Medical Geology"?

The definition of medical geology as *the scientific discipline that examines the impacts that geologic materials and processes have on human and ecosystem health* includes both natural and anthropogenic sources of potential health problems, and implies that wildlife and plant diseases are included. In contrast to the emphasis on treatment and cure that the term "medical" implies, work in this field is more accurately described as "public health" because of its focus on prevention. The consensus reached at a recent conference was that linguistic precision should be compromised in favor of a less burdensome and complex

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Correspondence to: Joseph E. Bunnell, e-mail: jbunnell@usgs.gov

term than proposed alternates. The most accurately descriptive term for this field of research, hydrobiogeochemoepidemiopathoecology, will not be used for obvious reasons. The working group, Medical Geology: Earth Systems, Resource Use and Human Health, was convened in Washington, DC on June 7–8, 2002 at the *Healthy Ecosystems/Healthy People* conference sponsored by the International Society for Ecosystem Health (ISEH). The working group agreed to continue using the term "medical geology," recognizing that the more important issue is to emphasize the broad definition as stated above. While "medical geology" is less than perfect to describe this discipline, it is easy to use and remember, and is accessible to policy-makers and the public—two groups identified as critical in outreach and promotion activities.

The general goals of the working group were to: (1) raise the visibility of medical geology to the Ecosystem Health community; (2) present a wide array of examples of medical geology case studies from around the world; and (3) reach consensus on a number of issues critical to the growth and development of this exciting new field. Case study presentations on the 1st day were augmented by lively question and answer sessions. The 2nd day consisted of a roundtable discussion: major issues discussed included the lessons learned so far in the development of this field, and what the priorities should be in future medical geology research. Additionally, the working group sought key recommendations for how this field can best enhance its growth, including attracting collaborators and funding.

Promotion/Advocacy

The working group discussed ways to promote the growth and expand the credibility of medical geology. The International Union of Geological Sciences (IUGS) has recently created a Medical Geology Initiative directly under its Executive Committee. The affiliation between this Union and the International Council of Scientific Unions (ICSU), and furthering existing ties to the United Nations Educational, Scientific and Cultural Organization (UNESCO), should help raise the visibility of this discipline's emergence.

In Washington, DC, the National Museum of Health and Medicine on the Walter Reed Army Hospital campus has a permanent exhibit that illustrates how medical geology is used by its parent organization, the Armed Forces Institute of Pathology (AFIP) to study health problems associated with arsenic. The exhibit, "Research Matters: Environmental and Toxicological Effects of Arsenic," explains how geoscience tools are complementing the skills of biomedical and environmental professionals to understand exposure to, and effects of, toxic metals such as arsenic. Also affiliated with the AFIP is the newly established Medical Geology Registry. This clearinghouse of information and resources should greatly facilitate training and education of future medical geologists. It should be beneficial to create a new repository for archived samples relevant to this discipline under the oversight of the Registry.

The medical geology community has been represented in symposia at regional and national meetings of the Geological Society of America (GSA). *Scientific American* magazine used the term "Medical Geology" for the first time in the February 2002 issue (Simpson, 2002). The US Geological Survey (USGS) is now hosting a Medical Geology web page (Bunnell, 2004). One book has been published on the topic (Skinner and Berger, 2003), and a textbook on *Medical Geology* is currently in preparation (Selinus, in press).

The working group recommended the creation of a Medical Geology Publications Advisory Board. This body will help steer authors to appropriate journals. Presently, medical geology papers are being published in a wide variety of journals. The group felt that the Board could help the development of the field by channeling submissions to fewer journals, thus avoiding the birth of yet another new journal. *The Journal of Toxicological Pathology* expressed interest in adding a Medical Geology editorial section, and the *Journal of Environmental Geochemistry and Health* will consider featuring a series of special editions devoted to medical geology. *The American Mineralogist* is also entertaining the idea of showcasing this field.

The working group agreed that a new professional society for medical geology should not be started at this time. However, the group concluded that some steps should be taken to formalize the international community of medical geologists. Expanding on current efforts to link medical geology with existing organizations is one efficient way to effect this. An excellent example is provided by this Working Group, which met under the auspices of the International Society for Ecosystem Health (ISEH). Other suggestions included the creation of Medical Geology Sections within the Geological Society of America and the Ecological Society of America.

One clear method to promote the growth and development of the field is to create a small fund to finance monetary awards at high-school level Science Fairs. Doing so will generate visibility for the field among impressionable budding medical geologists. Other suggestions involving formal educational institutions included:

- offering a week-long graduate course at several universities,
- organizing a postdoctoral-level short course under the auspices of the NATO Advanced Study Institutes, and
- continuing the development of a certificate program, ultimately leading to a degree program, in Medical Geology at George Washington University's School of Public Health—an activity already initiated in conjunction with the USGS and the AFIP.

Ultimately the quality of research will be medical geology's most effective promotional tool. Sharing tools and methodologies with partners in the biomedical and public health communities is to be encouraged, as those investigators may not be aware of the possibilities that exist by analyzing samples with instruments and techniques common to geoscientists. Such collaboration should be mutually beneficial because expanding the communal knowledge of methodologies will help all parties to learn to ask the right questions and better focus the research. These ideas are aimed at strengthening this transdisciplinary field by cross-fertilization, leading to hybrid vigor!

Priorities

A number of topics were raised as priorities for medical geology research. Two themes emerged as overriding priorities: (1) the study of trace elements, especially their bioavailability; and (2) a need to establish baseline, or background, levels of contaminants/xenobiotics/potentially harmful but naturally-occurring materials in water, soil, air, food, and animal tissue. Baseline/background determination is also critical to monitoring weapons of mass destruction; without such knowledge, it may be much more difficult to know when an anomaly occurs. Additional research priorities include radioactivity, earth materials, and infectious diseases. One priority should be to solve a high-profile medical geology problem, such as Balkan endemic nephropathy (Orem and Tatu, 2001).

In the short term, the working group felt that the medical geology community should determine the geographic distribution of diseases, and make maps of them available to the public. Medical geologists should study the relationship of trace metals to specific diseases. All of the information on medical geology case studies should be deposited in one place, such as the IUGS Medical Geology website (Selinus, 1996). As a general theme, the group stressed the importance of using geographic information systems (GIS). These efforts should help ensure that we gain some handy success stories to point out in support of our outreach efforts.

A number of other items were raised as being important in determining the course of future research directions, but were not deemed immediate priorities. For instance, are there medical geology issues related to construction materials? A system for establishing and reporting standards for consumer products could be created. Better understanding of pathogens carried by dust should be emphasized. Effects of deficiencies and excesses of trace elements and nutrients in diets need to be better understood. There are likely to be exposure pathways yet to be discovered or fully appreciated. Global change as it affects ecosystem health and development of predictive models should be emphasized. Observations of GIS-based correlations between apparent human health problems and environmental factors must make use of spatio-temporal statistical analysis; biophysical, pathological, and toxicological mechanistic techniques must be integrated to demonstrate biological plausibility. Medical geologists need to determine what sampling needs to be routinely done. Processes and mechanistic links need to be further explored. For example, how do metal solubilities, isotopes, modes of occurrence, etc., affect bioavailability? Novel applications of existing tools should be developed. A centralized repository, archive, or reference collection to enable the identification, collection, and validation of materials (e.g., tissues) that indicate origins of disease should be established. Finally, continuing to discover research gaps remains a pivotal effort in this rapidly evolving field.

Key Recommendations

One of medical geology's ultimate goals should be global baseline/background level monitoring. The geology, soils, and plants should be characterized in detail globally, using a consistent set of methodologies. More synthesis studies are needed. The needs of medical geologists should be communicated to appropriate partners in the medical community. For instance, mortality reporting criteria are highly variable. A system for accurately determining and recording cause of death must be standardized. Long-term monitoring and tracking of as wide a variety of geologic materials as possible is to be promoted, given the inability to predict what issues will become major problems in the future. By doing so, our ability to detect changes in the environment will improve; based on sensible uses of models, potentially deleterious changes may be predicted. When selecting which variables to monitor, medical geologists must consider the realm of civics; i.e., practical matters such as laws and regulations. Links to the agricultural sector must be built, especially with those working with foods. Public awareness of the benefits of medical geology needs to increase to generate positive attitudes that will facilitate recruitment. A recurring theme from the working group was the need to assemble presently disparate information into one place (e.g., a website including articles, abstracts, unpublished theses/dissertations, a listserv, and a virtual journal).

Conclusions

An important task is to foster acceptance of the subdiscipline medical geology. This may facilitate support for research by raising awareness among funding agencies and decision-makers. The general public must be educated on the value of this field, not only for its promise of finding practical, effective solutions to serious public health problems, but because people can encourage their elected leaders to champion this important cause. Given the philosophy and goals of the ISEH, a liaison between the Society and the IUGS Medical Geology Initiative would likely benefit both organizations. These complementary communities together can forge a strong, self-sustaining interdisciplinary scientific discipline—Medical Geology.

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