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Editorial

Evolution from Medical Geology to GeoHealth and future development prospects

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1. Introduction

From time immemorial the natural environment has impacted the health of plants, animals and humans. Although many of the impacts are negative causing a wide range of non-communicative health problems, the natural environment also provides the necessary nutrients and essential elements that sustain life. For millennia various cultures have been aware of health impacts of the environment and much of the early literature offered advice as to what minerals or rocks were to be used to address these issues. However, formal scientific studies are a relatively recent development. This paper provides a brief history of this emerging discipline from prehistoric times to current activities as well as a look into the future.

GeoHealth, also known as Medical Geology, Geology and Health and Geomedicine, is the discipline that focuses on the natural environment's impacts, both positive and negative, on living organisms – plants, animals, and humans. The natural environments and natural materials impact the health of hundreds of millions of people annually. The natural materials that impact health include minerals, trace elements, radioactivity, airborne particulates, and naturally occurring organic compounds. In addition, geologic processes such as volcanic eruptions, earthquakes, tsunamis, and landslides have both short-and-long-term impacts on human health. In addition, gravity, wind, water, and ice play important roles in modifying the geologic materials by reducing particle size, changing valence states, combining or separating elements and transporting these materials to sites where people and animals are exposed to them. When it was first recognized that geologic materials and geologic processes impact health is lost in the mist of history but evidence indicates that the awareness of the impacts of geologic materials and processes predates the emergence of our species – *Homo sapiens*. This paper will provide a brief overview of the evolving recognition of the impacts of the natural environment on human health and the development of the formal discipline – GeoHealth – that seeks answers to these impacts.

2. Paleo-history

The realization that geologic materials and processes can be beneficial as well as harmful to human health dates back eons. At a two-million-year old site in Zambia inhabited by *Homo habilis*, a precursor to *Homo sapiens*, anthropologists found a white powder that they concluded was used by these early humanoids to settle upset stomachs or as a dietary supplement. The anthropologists based their conclusion on the facts that the white powder was not local and thus had to have been intentionally brought to the site. Furthermore, the white powder was the clay kaolin an ingredient that had been used in popular medications such as Kaopectate to address mild-to-moderate diarrhea and related digestive issues. How did these early humanoids learn to use this geologic material for medicinal purposes? It is likely that humanoids and early humans learned the health benefits of rocks and minerals from observing animals. The practice of ingesting soils and mud, known as geophagy, is frequently observed in wild mammal populations. Mammals of several species such as giraffes, elephants, monkeys, elk, and rhinoceroses have been observed practicing geophagy (Fig. 1). The soil eaten is commonly from spatially limited locations called mining sites or salt licks. It has been suggested that elephants even mine for the nutrients.

It is not hard to imagine early humanoids mimicking the animals and ultimately realizing that there are benefits to this process. Even today, geophagy is still practiced by people on every continent. Eventually, the practice of using geologic materials for health benefits became codified in the earliest writing of ancient civilizations.

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Fig. 1. An animal eating soil for essential nutrients. (Courtesy to Michael Haworth; https://howieswildlifeimages.com/2017/05/26/chobe-hooves/)

3. Ancient history

More than 4000 years ago Chinese philosophers and other ancient writers recognized the relationship between the environment and human health (Table 1). Examples of early Chinese publications dealing with what we now refer to as GeoHealth includes:

• Huai Nan Zi (BCE 180–BCE 123) is a book of collective works with descriptions of the relationship between people's appearance, health status, and geographical conditions, drinking water, food, climate, and season.

• Zhu Bing Yuan Hou Lun (source of the disease), summarizing the previous ancient Chinese medical descriptions of various diseases and treatment.

• Lu Shi Chun Qiu (239 BCE) the first book with a clear description of the relationship between drinking water and health in China.

• Huang Di Nei Jing (475 BCE–AD 220) is devoted to the cause and prevention of diseases.

In Traditional Chinese Medicine (TCM), minerals such as gypsum (for fever), talc (for urinary infection), cinnabar (as a sedative), and hematite (for headaches) are commonly used, reflecting a long-standing understanding of geologic contributions to health.

4. Middle ages to recent times (1600–1970)

During this time period the formal sciences of chemistry and geology separated from medical science but links remained. The link beween medical science and geology was dominated by the British. Many British scientists trained in medicine who contributed to various aspects of geology, including GeoHealth. Lewis (1931) states that the subject of mineralogy was taught as part of medical training, because knowledge of minerals was required for the fabrication of medicines, thus medical men were drawn into mineralogy and geology.

Several detailed books deal with this subject including *A History of Geology and Medicine* by Duffin et al. (2013) and *Geology and Medicine: Historical Connections* by Duffin et al. (2017).

5. Recent history (1970s–1990s)

During this period there were several attempts to develop a discipline focused on what we now call GeoHealth issues. For example, the *Society for Environmental Geochemistry and Health* (SEGH: https://segh.net/) was established in 1971 to provide a forum for scientists from various disciplines to work together to understand the interaction between the geochemical environment and the health of plants, animals, and humans. The associated journal–*Environmental Geochemistry and Health* was established about the same time. Key reports from the U.S. National Academies addressed the links between trace elements and diseases like cancer and cardiovascular disorders.

However, progress slowed in the 1980s due to funding constraints and lack of formal recognition. Correlation was often mistaken for causation, undermining credibility.

In 1990, Jul Lag of Norway tried to revive the discipline with his book *Geomedicine*. However, the resurgence of this discipline had to wait another 20 years.

6. Modern history

It is not often that a scientific discipline can identify the location where the seeds of its development were planted but

Table 1. Examples of early use of geologic materials for health purposes (from various sources).

When	Where	What	Why
3000–2400 BC	Mesopotamia	Salt, saltpeter	?
3000 BC	India	Salt, asphalt	Diabetes
2000 BC	China	HgO_2 arsenolite, pearls, cinnabar	Various illnesses
1600 BC	Egypt	Antimony sulfide, copper acetate, sodium carbonate	Eye disease
BC	Xizang (China)	Pearls, coral, calcite, turquoise, soil	Various illnesses
BC	Africa	Soil	Various illnesses
BC	Greece and Rome	Terra sigillata, metals	Antidotes for stomach aches and poisons
800 AD	Central America	Minerals	Antidotes for poisons
1000 AD	Islam	Mercury compounds	Various illnesses
1200 AD	Europe	Gold	Various illnesses

GeoHealth might be an exception. It can be argued that modern GeoHealth began in Guizhou Province, China (Finkelman RB and Centeno JA, 2020). In the 1980s Prof. Zheng Baoshan and his students recognized that a large number of people in Guizhou Province had clinical symptoms of arsenic poisoning, fluorine exposure, selenosis, and other diseases caused by exposure to potentially toxic trace elements or due to deficiency of essential elements (Zhang BS and Wang B, 2009). Their publications and invitations to scientists to visit the Province ultimately resulted in increased attention to the health impacts of the natural environment and the formation of international and national scientific societies, the publication of at least 40 books, thousands of technical articles, short courses presented in more than 50 countries, international conferences,

In 2005 the award winning book *Essentials of Medical Geology* (Selinus O et al., 2005) became a landmark publication. Since then, more than 40 books have been published on this subject including a Chinese translation (Zhang BS and Wang B, 2009) and an updated edition of the *Essentials of Medical Geology* by (Selinus O et al., 2005; Centeno J et al. 2016; Randive K and Godbole P, 2025).

The societies focusing on GeoHealth issues include the International Medical Geology Association (IMGA), the Geological Society of America's Geology and Health Division, the Society of Environmental Geochemistry and Health (SEGH), the American Geophysical Union's GeoHealth Section that produces the GeoHealth journal. There are also a number of national organizations (e.g. Iran, India, Turkey). A series of Medical Geology conferences MEDGEO have been held in various countries every two years since 2005.

7. Current activities

GeoHealth is alive and well. Here are just a few selected examples of GeoHealth recent activities. The MEDGEO conference series has become a central platform, with its 11th edition in Aviero, Portugal in the fall of 2025 (MEDGEO 25 ISEG); the 39th International Conference on Environmental Geochemistry and Health was held in Nigeria in 2024; the 37th International Geologic Congress in 2024 in South Korea had a session on Medical Geology. The US Geological Survey publishes the *GeoHealth Newsletter* quarterly. The president of the International Union of Geological Sciences is Dr. Hassina Mouri, from South Africa, a practicing medical geologist. The first of its kind medical geology research center has been established in Nigeria - The Jose A. Centeno International Center for Medical Geology Research at Nasarawa State University, Keffe, Nigeria. In 2023 the Kingdom of Saudi Arabia has funded a project to assess medical geology issues at several locations. A relatively new organization - the International Environmental and Health Sciences Consortium offers consultation, training and research support on medical geology and health science issues.

All these activities and more are dedicated to what is now called GeoHealth. In China, Medical Geology /GeoHealth has seen comprehensive development in response to the national "Healthy China Initiative". The China Geological Survey and various provincial geological bureaus have established dedicated funding programs to support related research. They are currently carrying out several health-oriented geological surveys, especially in areas with high background levels of certain elements. Their projects focus on environmental geochemistry, health risk prevention, and building Model GeoHealth Villages. Additionally, the Geological Society of China has set up a Medical Geology Committee, which organizes academic conferences and publishes thematic volumes to facilitate the exchange of research findings and recent progress in the field. Furthermore, a Working Group on GeoHealth has been established under the International Medical Geology Association (IMGA) to promote international collaboration and advance GeoHealth research with Chinese participation. Much more can be learned about these activities in the other papers in this special issue and at the *China Geology* website.

8. Future

Despite all that has been accomplished to date there are still numerous opportunities for medical geology researcher. Some of these opportunities include:

(i) Health impacts of climate change. Shifting climate patterns could bring medical geology issues to new regions and minimize their impacts in other areas.

(ii) Impacts of natural disasters such as volcanic eruptions, earthquakes, landslides, flooding, etc. The long-term health impacts of these natural phenomena have not been adequately studied.

(iii) Urban medical geology. Opportunities include: the health impacts of natural dust on urban populations may increase; the uptake of potentially harmful elements from soils in urban gardens; release of arsenic, copper and chromium from pressure treated wood.

(iv) Veterinary geology. Many different species of animals seek geologic materials to satisfy their needs for essential elements. Perhaps they can be used for geochemical prospecting. Animals also succumb to toxic elements such as selenium and may be useful as sentinels for identifying areas to avoid.

(v) Occupational health. Millions of people engaged in occupations such as farming, construction, factory work, mining, etc.. More work needs to be done to determine what these workers are exposed to and how to minimize the health impacts.

(vi) Global dust impacts. Dust storms transport particles across the globe. More work should be done on assessing the health impacts.

(vii) Relationship of minerals with microbes. Why do some minerals host colonies of bacteria, viruses, and fungi while some mineral kill these pathogens?

(viii) Soil Health and Geochemical Burden. Soils are fundamental to human and ecosystem health, yet many are degraded by persistent pollutants, including heavy metals, microplastics, antibiotics, and pesticide residues. A comprehensive geochemical characterization of urban, suburban, and agricultural soils is essential to assess both risks and benefits —particularly the presence and bioavailability of beneficial elements such as selenium.

(ix) Water Quality and Geochemistry. Much like soils, surface and groundwater resources have been compromised by human activity. Systematic assessment of harmful components (e.g. fluoride, cyanide, heavy metals) and beneficial elements is crucial to safeguard public health.

(x) Atmospheric Geochemistry and Human Health. The atmosphere plays a critical role in human and animal well-being. Medical geology research should target key atmospheric health hazards such as: radon gas exposure, ozone depletion and increased UV radiation, smog and air pollution, the chemical composition of airborne dust particles.

Pursuing these important research areas can attract interdisciplinary collaboration and position GeoHealth as a globally recognized and impactful emerging discipline.

9. Concluding comments

In the past 25 years much effort has gone into recognizing medical geology issues around the globe. Scientists have made some progress in addressing a number of these issues but much more still needs to be done to prevent these unnecessary health problems. We must consider the fact that most medical geology research focuses on the obvious acute health issues but there are many more people with chronic health issues that should be addressed as well. At the same time, we must also focus on identifying and utilizing beneficial geological resources that promote human health. This proactive approach shifts the paradigm from a disease-centered model to one that prioritizes overall health and well-being (health-centered). Ultimately, this transformation will help establish GeoHealth as a forward-looking and socially relevant interdisciplinary field.

GeoHealth survey represents a transformative convergence of geosciences and public health, offering innovative solutions to environmental health challenges. This framework integrates a rich historical foundation, problem-oriented research approaches, advanced technical methodologies, and service-driven outcomes to address critical issues, including drinking water safety, soil quality, endemic diseases, resource utilization, and data accessibility. By overcoming challenges through interdisciplinary collaboration, technological innovation, and stakeholder engagement, GeoHealth survey can significantly contribute to the "Healthy China" initiative and global sustainable development. The future lies in leveraging intelligentization, globalization, and serving the livelihood to amplify impact, ensuring that GeoHealth survey remains at the forefront of environmental health management.

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