

Medical Geology

International Year of Planet Earth

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The book series is dedicated to the United Nations International Year of Planet Earth. The aim of the Year is to raise worldwide public and political awareness of the vast (but often under-used) potential of Earth sciences for improving the quality of life and safeguarding the planet. Geoscientific knowledge can save lives and protect property if threatened by natural disasters. Such knowledge is also needed to sustainably satisfy the growing need for Earth's resources by more people. Earths scientists are ready to contribute to a safer, healthier and more prosperous society. IYPE aims to develop a new generation of such experts to find new resources and to develop land more sustainably.

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Medical Geology

A Regional Synthesis

 Springer

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Foreword

The International Year of Planet Earth (IYPE) was established as a means of raising worldwide public and political awareness of the vast, though frequently under-used, potential the Earth Sciences possess for improving the quality of life of the peoples of the world and safeguarding Earth's rich and diverse environments.

The International Year project was jointly initiated in 2000 by the International Union of Geological Sciences (IUGS) and the Earth Science Division of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). IUGS, which is a Non-Governmental Organisation, and UNESCO, an Inter-Governmental Organisation, already shared a long record of productive cooperation in the natural sciences and their application to societal problems, including the International Geoscience Programme (IGCP) now in its fourth decade.

With its main goals of raising public awareness of, and enhancing research in the Earth sciences on a global scale in both the developed and less-developed countries of the world, two operational programmes were demanded. In 2002 and 2003, the Series Editors together with Dr. Ted Nield and Dr. Henk Schalke (all four being core members of the Management Team at that time) drew up outlines of a Science and an Outreach Programme. In 2005, following the UN proclamation of 2008 as the United Nations International Year of Planet Earth, the "Year" grew into a triennium (2007–2009).

The Outreach Programme, targeting all levels of human society from decision-makers to the general public, achieved considerable success in the hands of member states representing over 80% of the global population. The Science Programme concentrated on bringing together like-minded scientists from around the world to advance collaborative science in a number of areas of global concern. A strong emphasis on enhancing the role of the Earth sciences in building a healthier, safer and wealthier society was adopted – as declared in the Year's logo strap-line "Earth Sciences *for* Society".

The organisational approach adopted by the Science Programme involved recognition of ten global themes that embrace a broad range of problems of widespread national and international concern, as follows.

- Human health: this theme involves improving understanding of the processes by which geological materials affect human health as a means identifying and reducing a range of pathological effects.
- Climate: particularly emphasises improved detail and understanding of the non-human factor in climate change.

- Groundwater: considers the occurrence, quantity and quality of this vital resource for all living things against a background that includes potential political tension between competing neighbour-nations.
- Ocean: aims to improve understanding of the processes and environment of the ocean floors with relevance to the history of planet Earth and the potential for improved understanding of life and resources.
- Soils: this thin “skin” on Earth’s surface is the vital source of nutrients that sustain life on the world’s landmasses, but this living skin is vulnerable to degradation if not used wisely. This theme emphasizes greater use of soil science information in the selection, use and ensuring sustainability of agricultural soils so as to enhance production and diminish soil loss.
- Deep Earth: in view of the fundamental importance of deep the Earth in supplying basic needs, including mitigating the impact of certain natural hazards and controlling environmental degradation, this theme concentrates on developing scientific models that assist in the reconstruction of past processes and the forecasting of future processes that take place in the solid Earth.
- Megacities: this theme is concerned with means of building safer structures and expanding urban areas, including utilization of subsurface space.
- Geohazards: aims to reduce the risks posed to human communities by both natural and human-induced hazards using current knowledge and new information derived from research.
- Resources: involves advancing our knowledge of Earth’s natural resources and their sustainable extraction.
- Earth and Life: it is over two and half billion years since the first effects of life began to affect Earth’s atmosphere, oceans and landmasses. Earth’s biological “cloak”, known as the biosphere, makes our planet unique but it needs to be better known and protected. This theme aims to advance understanding of the dynamic processes of the biosphere and to use that understanding to help keep this global life-support system in good health for the benefit of all living things.

The first task of the leading Earth scientists appointed as Theme Leaders was the production of a set of theme brochures. Some 3500 of these were published, initially in English only but later translated into Portuguese, Chinese, Hungarian, Vietnamese, Italian, Spanish, Turkish, Lithuanian, Polish, Arabic, Japanese and Greek. Most of these were published in hard copy and all are listed on the IYPE website.

It is fitting that, as the International Year’s triennium terminates at the end of 2009, the more than 100 scientists who participated in the ten science themes should bring together the results of their wide ranging international deliberations in a series of state-of-the-art volumes that will stand as a legacy of the International Year of Planet Earth. The book series was a direct result of interaction between the International Year and the Springer Verlag Company, a partnership which was formalised in 2008 during the acme of the triennium.

This IYPE-Springer book series contains the latest thinking on the chosen themes by a large number of Earth science professionals from around the world. The books are written at the advanced level demanded by a potential readership consisting of Earth science professionals and students. Thus, the series is a legacy of the Science Programme, but it is also a counterweight to the Earth science information in

several media formats already delivered by the numerous National Committees of the International Year in their pursuit of world-wide popularization under the Outreach Programme.

The discerning reader will recognise that the books in this series provide not only a comprehensive account of the individual themes but also share much common ground that makes the series greater than the sum of the individual volumes. It is to be hoped that the scientific perspective thus provided will enhance the reader's appreciation of the nature and scale of Earth science as well as the guidance it can offer to governments, decision-makers and others seeking solutions to national and global problems, thereby improving everyday life for present and future residents of Planet Earth.



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International Year of Planet Earth



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Preface

This book series is one of the many important results of the International Year of Planet Earth (IYPE), a joint initiative of UNESCO and the International Union of Geological Sciences (IUGS), launched with the aim of ensuring greater and more effective use by society of the knowledge and skills provided by the Earth Sciences.

It was originally intended that the IYPE would run from the beginning of 2007 until the end of 2009, with the core year of the triennium (2008) being proclaimed as a UN Year by the United Nations General Assembly. During all three years, a series of activities included in the IYPE's science and outreach programmes had a strong mobilizing effect around the globe, not only among Earth Scientists but also within the general public and, especially, among children and young people.

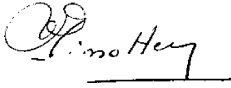
The Outreach Programme has served to enhance cooperation among earth scientists, administrators, politicians and civil society and to generate public awareness of the wide ranging importance of the geosciences for human life and prosperity. It has also helped to develop a better understanding of Planet Earth and the importance of this knowledge in the building of a safer, healthier and wealthier society.

The Scientific Programme, focused upon ten themes of relevance to society, has successfully raised geoscientists' awareness of the need to develop further the international coordination of their activities. The Programme has also led to some important updating of the main challenges the geosciences are, and will be confronting within an agenda closely focused on societal benefit.

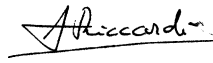
An important outcome of the work of the IYPE's scientific themes includes this thematic book as one of the volumes making up the IYPE-Springer Series, which was designed to provide an important element of the legacy of the International Year of Planet Earth. Many prestigious scientists, drawn from different disciplines and with a wide range of nationalities, are warmly thanked for their contributions to a series of books that epitomize the most advanced, up-to-date and useful information on evolution and life, water resources, soils, changing climate, deep earth, oceans, non-renewable resources, earth and health, natural hazards, megacities.

This legacy opens a bridge to the future. It is published in the hope that the core message and the concerted actions of the International Year of Planet Earth throughout the triennium will continue and, ultimately, go some way towards helping to establish an improved equilibrium between human society and its home planet. As

stated by the Director General of UNESCO, Koichiro Matsuura, “Our knowledge of the Earth system is our insurance policy for the future of our planet”. This book series is an important step in that direction.



R. Missotten
Chief, Global Earth Observation Section
UNESCO



Alberto C. Riccardi
President
IUGS

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Introduction

Medical Geology – A Regional Synthesis

This book, part of a series that will be a legacy to the International Year of Planet Earth, focuses on earth and health, or, as this subject is commonly referred to, medical geology. Medical geology is the science dealing with the relationship between natural geological factors and health in man and animals. It does not deal with pure anthropogenic factors. There is, however, a gray zone. The arsenic catastrophe in Bangladesh is caused by geology factors (naturally occurring arsenic in the groundwater); however, the health problem was triggered by boring millions of tube wells to bring this water to the surface. Mining brings ores and minerals from depth to the surface environment. Unfortunately, there are often serious health consequences caused by oxidation of the ores, liberation of the minerals, etc. Organic pollutants are generally not an issue for medical geology because they are usually anthropogenic; however, there are serious health problems when these compounds are transported by groundwater and deposited in soils. Geoscientists and the information they generate can have important roles to play even in these 'gray zones.'

Medical geology is a rapidly expanding field concerned with the relationship between natural geological factors and human and animal health, including understanding the influence of environmental factors on the geographical distribution of health problems. Medical geology brings together geoscientists and medical/public health researchers to address health problems caused or exacerbated by geological materials; ultimately, it is only with multidisciplinary collaborations that interventions can be devised to reduce morbidity and mortality from such problems. Medical geology also deals with the many health benefits of geologic materials and processes.

Rocks are the source of most chemical elements found on the earth. Many elements in the right quantities are essential for plant, animal, and human health. Most of these elements enter the human body via food and water in the diet and through the air that we breathe. Through weathering processes, rocks break down to form soils on which crops and animals that constitute the food supply are raised. Drinking water moves through rocks and soils as part of the hydrological cycle. Much of the natural dust and some of the gases present in the atmosphere are the result of geological processes. Elements that are essential for our well-being and non-elements, some potentially toxic, exist side-by-side in bedrock or soils and may become a direct risk for human and animal health if present in low quantities (deficiency) or if present in excessive quantities (toxicity). The inability of the environment to provide the correct chemical balance can lead to serious health problems. The links between environment and health are particularly important for subsistence populations that are heavily

dependent on the local environment for their food supply. Trace element deficiencies in crops and animals are commonplace over large areas of the world and mineral supplementation programs are widely practiced in agriculture.

Infectious diseases in humans are also dramatically affected by the geological environment, albeit indirectly. Geological forces shape the environments in which microbes thrive, sometimes creating opportunities for the emergence of infectious diseases as major public health problems.

Because of the emergence of these health problems, there has been a growing awareness of the interaction between the natural environment and animal and human health for the past several decades – medical geology. More and more people in developed and developing countries are becoming aware of the potential health impacts caused by geologic processes along with human activities of all kinds that redistribute elements and minerals from sites where they are harmless to places where they adversely impact animal and human health.

Medical geology issues transcend political boundaries, and many issues are found in countries around the globe putting at risk the health of billions of people. A few examples will be mentioned here.

Arsenic in drinking water is one example of international concern. Millions of people in Bangladesh and West Bengal, India, suffer from exposure to high arsenic levels in drinking water. Also millions of people in many countries on other continents are suffering from arsenic exposure or are at risk of arsenic poisoning, a potentially fatal health problem.

High **fluorine** content in drinking water is another medical geology issue causing problems with teeth and limbs all over the world. Fluorides are ubiquitous in nature and are present in rocks, soil, water, plants, foods, and even air. Excessive ingestion of fluoride through water, food, or dust causes acute toxicity or a debilitating disease called ‘fluorosis.’ Chronic fluoride poisoning is more common and can affect animals as well as humans. Excessive intake during pre-eruptive stage of teeth leads to dental fluorosis and further continued ingestion over years and decades causes bony or skeletal fluorosis.

Iodine deficiency resulting in health problems, such as goiter, affects many millions of people and is a consequence of the local geology, deficiency of the element iodine in bedrock and soils and thus a deficiency of iodine in the diet.

Selenium is an essential trace element. However, selenium deficiency (due to soils low in selenium) has been shown to cause severe physiological impairment and organ damage. Several areas in the world have been demonstrated to have soils deficient in selenium. Selenium deficiency is particularly prevalent in China.

Geology is the most important factor controlling the source and distribution of **radon**. Relatively high levels of radon emissions are associated with particular types of bedrock and unconsolidated deposits, for example, some, but not all, granites, phosphatic rocks, and shales rich in organic materials. Inhalation of radon was a severe occupational hazard for uranium miners, commonly resulting in fatal lung cancer.

Balkan endemic nephropathy (BEN), an irreversible kidney disease associated with renal pelvic cancer, was thought to be confined to several rural regions of the Balkans, but recently it has been discovered in other parts of the world by medical geology scientists.

Atmospheric dust is a global phenomenon. Dust storms from Africa regularly reach the European Alps and the Western Hemisphere. Asian dust can reach

California in less than a week, some of the dust ultimately crossing the Atlantic and reaching Europe. The ways in which mineral dust impacts upon life and health are wide ranging. These include changes in the planet's radiative balance, transport of disease bacteria to densely populated regions, dumping of wind-blown sediment on pristine coral reefs, general reduction of air quality, provision of essential nutrients to tropical rainforests, and transport of toxic substances. Mobilization of dust is both a natural and an anthropogenically triggered process.

This book will cover all these aspects and many more, on a global and regional scale. Many specialists from all around the globe have contributed with their expertise. The book gives many examples of environmental health issues from different continents and also an overview of what is going on now in the field of medical geology. *A truly international book like this also reflects the different scientific cultures from all around the world with different terminologies and different ways of thinking. The readers must bear this in mind when reading the book.*

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