Citation:

Bobrowsky P., V.S. Cronin, G. Di Capua, S.W. Kieffer, S. Peppoloni (2017). The Emerging Field of Geoethics. In: Scientific Integrity and Ethics with Applications to the Geosciences, edited by L.C. Gundersen. Special Publication American Geophysical Union, John Wiley and Sons, Inc.

CHAPTER 6:

THE EMERGING FIELD OF GEOETHICS

Peter Bobrowsky[1,5], *Vincent S. Cronin*[2,5], *Giuseppe Di Capua*[3,5], *Susan W. Kieffer*[4,5], *Silvia Peppoloni*[3,5]

[1] Geological Survey of Canada, Sidney, British Columbia, Canada.
[2] Department of Geology, Baylor University, Texas, USA.
[3] Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy.
[4] Department of Geology, University of Illinois, Illinois, USA.
[5] International Association for Promoting Geoethics (www.geoethics.org).

ABSTRACT

The geosciences need practitioners who possess an ethical conscience and the desire to act responsibly. Ethically responsible geoscientists will achieve success and satisfaction by carrying out excellent research and professional activities, and by maintaining honest and open collaborations with colleagues. Such individuals will be able to contribute to building a resilient society, be better prepared to face global economic and environmental challenges and be willing to take concrete actions for the conservation of the geo- environment. Geoethics provides ethical, social, and cultural values for the scientific community and for society as a whole. Geoethics represents a new vision of a world in which it is possible to maintain a more balanced relationship between humans and nature, considering modern economic and social development expectations. This chapter illustrates some aspects of geoethics, provides an overview of its basic values and themes, and highlights prominent global issues that involve geoethics, including climate change, geo-risks, land management, exploitation of geo-resources, and sustainability. The International Association for Promoting Geoethics (IAPG) provides a multidisciplinary platform for discussion, a place where multidisciplinary collaboration can strengthen the development of geoethics from a scientific and philosophical perspective, in order to better introduce geoethical values into society.

INTRODUCTION

Many scientists and prominent individuals claim that the impact of people on the natural evolution of the planet has reached a level of alarm (Sachs 2014, Pope Francis 2015). Although scientific and engineering advances often give society the capability of finding solutions to problems, humans and institutions frequently pay little attention to the negative effects of their actions, particularly those that may arise in the medium and long term. For several years, the scientific community has debated which geo-environmental indicator/parameter should be used to formalize the Anthropocene (Crutzen 2002) as a new geologic epoch, an interval of time during which the global and local impacts of man-made actions on the dynamics of the Earth are visible in the geologic record (Lewis and Maslin 2015; Zalasiewicz et al. 2015).

In addition to the stratigraphic aspect, there is also a cultural aspect to be considered. Humans recognize themselves as an additional force of nature capable of producing or inducing changes on the geosphere and the biosphere. Thus they are aware that their actions can have an impact on the Earth's ecosystems. This awareness suggests that humans also recognize the clear responsibility and necessity to act to protect those ecosystems and to ensure the long-term safety for our species. Only a respectful approach to the geological and biological processes of the planet that takes into account different temporal scales of occurrence can avert the risk of entering into a state of non-sustainability for our growing needs of development, with inevitable but non-predictable consequences for the social, political, and economical balances.

From this perspective, the geosciences play a fundamental role in defining the limits of sustainability of the planet and in leading to behavior required to respect these limits. The Earth is made up of a set of complex, unique, and mutually necessary systems: the biosphere (the realm of all living organisms), and the geosphere (the land surface, the solid Earth, the hydrosphere, the cryosphere, and the atmosphere). These systems strongly interact with each other on a wide range of scales in the space-time continuum. The need to integrate many different skills to effectively address studies of Earth systems thus becomes evident. The awareness of how our technical actions impact the previously mentioned systems brings us to the ethical issue of determining what will best ensure the present and future preservation of life for all species, by seeking a balance between scientific-technological progress and the conservation of geodiversity and biodiversity.

Geoscientists have the particular and unique skillsets necessary to solve problems created by the exploitation of the Earth's mineral, energy, and water resources, the defense against natural hazards, the protection and enhancement of geodiversity, and the compilation of geo-environmental knowledge for society. However, the technical and professional skills used by geoscientists in solving complex problems can be most effective when accompanied by training that carefully considers the social and ethical implications of geological practice (Mogk and Geissman 2014; Mogk et al. this volume). If the behavior of geoscientists is not guided by geoethical principles, even scientifically competent individuals may not find and choose solutions that are equally respectful of the natural dynamics of our planet. Professional research and practice require geoscientists to consider the quality of the data, respect the scientific method, maintain a constructive attitude, and adopt critically constructive but collaborative approaches towards their scientific and professional communities.

Geoethics aims to provide a framework of values within which geoscientists can act in a conscious and responsible way within the profession while serving society. But geoethics can be much more. It can become a common way of thinking about the planet in a sustainable manner (Selle 2014), one that is widespread and shared in different cultural, social and economic contexts, a functional way through which to build (or rebuild) a healthier balance between humans and nature, thus contributing to a "mature" Anthropocene (Bohle 2015). Geoethics can provide a new understanding of geosciences as tools for appropriate management of the Earth. Geosciences are not only a collection of useful scientific and technical data and knowledge, but also represent a significant cultural resource capable of influencing our future while still considering the current and future complex of global problems affecting societies. A sustainable world can also be economically beneficial to society as a whole.

I. OVERVIEW

a. The origins of Geoethics

In the 1940's Aldo Leopold (1887-1948) proclaimed a need to develop a new relationship between humans and the natural environment and identified the concept of "conservation" as the ethical criterion upon which to base this new relationship, since "Conservation is a state of harmony between men and land" (Leopold, 1949). In the 1960's the development of environmental awareness resulted in the birth of several environmental movements that acted and continue to act with a perspective geared primarily to safeguarding the biosphere, although with important differences in their approaches to saving the Earth.

In the years that have followed, environmentalism has gradually become an articulated phenomenon, one which proposes different strategies towards protecting nature and biodiversity primarily as a result of different visions (Marshall, 1993). "Conservation Ethics" considers that "nature" must be preserved in a relationship of subordination to the needs of mankind. Because natural resources are functional to human life, society must exploit them in a sustainable way, through actions that allow their rational and prudent use, all the while being aware of their limits and potential for exhaustibility.

The "Ecologic Extension," a more eco-centric approach, points out that the value of nature to mankind must be balanced by the intrinsic value of nature itself. Therefore, this approach proposes taking strong and stringent actions to preserve the natural environment and therefore requires a limited exploitation of natural resources. Finally, the "Libertarian Extension," an extreme eco-centric approach, pushes for the adoption of policies strongly oriented towards the preservation of nature, severely if not completely limiting the ability of humans to act upon the Earth.

Environmental ethics oscillates between extreme positions, from anthropocentrism (Passmore 1974) to eco-centrism (Næss 1973, Devall and Sessions 1985). The former promotes the vision of humans as separate from nature, while the latter considers humans as an integral part of nature.

Geoethics rediscovers, expands, and enhances the cultural dimension of geoscience knowledge (Frodeman 1995; Frodeman and Baker 2000; Peppoloni and Di Capua 2012) as a basic element of a holistic vision that goes beyond the dualism between humans and nature. Geoethics emphasizes the ethical criterion of responsible human action towards the Earth (Peppoloni and Di Capua 2012), not only in its biotic components (biodiversity) but also in the abiotic (geodiversity).

The geologist Antonio Stoppani (1824-1891) introduced the concept of the "Anthropozoic Era" (Stoppani 1873). He identified humans as a new "geological force" and thus as an integral and essential part of nature. As an early populariser of geological knowledge, Stoppani thus became one of the pioneers of geoethics.

Geoethics recognizes the contingency of human evolution on the planet (Pievani 2009, 2012), identifies *Homo sapiens* as a geological force acting on the geological and biological environments, and assigns to humans an ethical responsibility that arises from the consciousness of being a modifier of Earth systems.

Near the end of the last century the more modern concept of the Anthropocene finally crystallized (Crutzen 2002). An intense scientific debate about this concept ensued. Because geology adheres to temporal and stratigraphic limits (Lewis and Maslin 2015; Zalasiewicz et al. 2015), geoethics is a discipline required in order to understand the inevitable consequences (positive and negative) of human progress, especially when we consider the enormous amount of energy and natural resources used for economic development and the wide environmental spaces occupied and modified by human beings. The incredible increase in population and the legitimate aspirations of every individual to improve his or her own material conditions can find in geoethics a frame of reference for values rooted in geological thinking, which has the peculiar characteristic of being able to analyze space and time in a perspective that goes beyond the human experience but that accepts the presence of people on the planet as a natural consequence of the unpredictability of natural evolution (Pievani 2009, 2012).

Geoethics provides a framework for any human action on the geosphere. The responsibility that derives from this framework is the basis of the semantic meaning of the word "ethics" (Peppoloni and Di Capua 2015). Therefore, the word "geoethics," as used starting from the early 1990's (Savolainen 1992; Cronin 1992), signifies the duty of mankind to behave responsibly and become the natural consciousness of the planet. To place humans at the center of the discussion on geoethics does not represent a new form of anthropocentrism but rather stresses that only by accepting their responsibility initially towards themselves, can humans become fully aware of their role as an active "geological" force. Then changes in the dynamics of Earth systems can be made, when necessary, through responsible behaviors and proper practices towards geodiversity and biodiversity (Ellis and Haff 2009).

As guardians and developers of geoscience knowledge and given their particular sensitivity towards natural systems, geoscientists must assume the responsibility of promoting of a new way of thinking about human lives in relation to Earth systems. The definition of geoethics proposed by Peppoloni and Di Capua (2015) summarizes this vision: "Geoethics consists of research and reflection on the values which underpin appropriate behaviors and practices, wherever human activities interact with the geosphere". It deals with the ethical, social, economic, and cultural implications of using Earth sciences for societal benefits, represents an opportunity for geoscientists to consider their activities under an ethical perspective, and provides an avenue for increasing societal awareness of problems related to geo-resources exploitation and energy supplies, geo-environmental changes and geo-hazards (Lucchesi and Giardino 2012; Peppoloni and Di Capua 2012).

b. Values

Geoethics addresses how geoscientists should manage their individual consciences, their behavior towards their colleagues, their stewardship of the Earth, the responsible development of geo-resources, and the mitigation of geo-hazards as well as the involvement of the public in education on geosciences and Earth's processes and their involvement in the development of important public policies. The responsible behavior of geoscientists is a key point of geoethics (Peppoloni and Di

Capua 2012). But responsible behavior requires a conscious decision. A choice is possible only when the freedom to choose exists. In other words, freedom of action is a founding value of geoethics. Geoethics and freedom are intimately connected. One cannot act responsibly and ethically if one is not free to choose between possible alternatives. Therefore, in conducting their activities geoscientists should consider if they are free from compromises and (or) conflicts of interest, including political, social, and psychological pressures. Geoscientists must conduct occasional self-assessments to determine if conditions allow them to make ethical choices in their activities. The individual dimension of each geoscientist is the basis of discussion within geoethics, to which the dimension related to the collaborative work is included.

Because geoscientists know the complexity of Earth systems, they are aware of the need to investigate and understand those systems through multidisciplinary, interdisciplinary, and transdisciplinary approaches (Choi and Pak 2006). Multiple approaches to geoscience problem solving are necessary in order to ensure completeness in analysis, an important requirement in examining problems that include many variables. The value of multiple approaches is that they involve the integration of different knowledge, skills, and experience as well as the sharing of scientific methods through professional collaboration, where openness to the comparison between colleagues with different ideas and the sharing of data, procedures, and results are routine. The same is true of geoethics as a discipline.

This particular sensitivity to and way of approaching nature make the geoscientist an indispensable figure within society. The commitment to serve the public's best interests is a fundamental duty of the responsible geoscientist. This commitment also implies an ethical duty to educate people about the importance of geosciences and transfer the information needed to build a knowledgeable society. Geoscientists possess knowledge that can benefit all. They can identify fundamental cultural and technical turning points in the sustainable and prudent management of geo-resources and energy and can suggest ways to mount effective defenses against geo-risks (Di Capua and Peppoloni 2014; GSL 2014; Lambert et al. 2013).

Sustainability is now one of the reference values of our modern culture (WCED 1987). Prolonged use of a resource well represents the need to find a balance between environmental protection and the development of the society. When it comes to geo-resources, true sustainability is in many cases either impractical or impossible. Nevertheless, in a wider vision, the concept of sustainability should not be related to a single resource (i.e., oil, gas, water) but rather to Earth systems as a whole. Sustainability should be the working paradigm for society as it focuses on ways to reduce the use of nonrenewable resources and to increase the use of renewable resources. In this perspective, shifts in the exploitation of resources ideally should not have an impact on the entire Earth systems, especially if they may jeopardize lives of humans and other living organisms. Geoscientists therefore have an ethical obligation to propose multi-disciplinary solutions that take into account the natural environment in a balanced global manner.

c. Themes

The field of study of geosciences is very broad and concerns all Earth systems. Geoethics first of all proposes itself as a discipline aimed at reflecting upon and discussing in scientific terms the cultural, ethical, and societal implications of the various geo-disciplines in relation to their different sectors of interest and application, with active contribution and input from other disciplines such as philosophy, sociology, and economics. In particular, geoethics:

- highlights the social role played by geoscientists and their responsibilities, focusing on the ethical, cultural, and economic repercussions that their choices may have on society and the environment (Peppoloni and Di Capua 2012; Wyss and Peppoloni 2015);
- promotes the cooperation of geoscientists with philosophers, sociologists, economists, biologists, chemists, psychologists, news media, and others in order to favor mutual cultural exchange, including their participation in the intellectual life of society and the development of their critical thinking (Cervato and Frodeman 2012; Peppoloni 2012a and 2012b);
- fosters the proper and correct dissemination of scientific studies, data, and results and promotes responsibility, integrity, expertise, and professionalism in all geoscientific research and practice, by providing guidance in promoting honesty and integrity in collaborative activities (AGI 2015; Mayer 2015; Peppoloni 2015; Peppoloni et al. 2015) and for defining data policies to permit wider circulation of information while at the same time respecting intellectual and public property;
- organizes effective teaching tools to develop awareness, share values, and increase responsibility amongst geoscientists, especially those in the early stages of their careers (Mogk and Geissman 2014);
- promotes geo-education as a way to emphasize the importance of geosciences and as a means of attracting young people to geoscience studies, with the ultimate goal of encouraging ethical and critical thinking and offering a new vision of the world to society;

- encourages critical analysis of the use and management of geo-resources by trying to find socio-economic solutions within the framework of sustainability for future generations (Lambert et al. 2013);
- deals with problems related to georisks management, communication, and education in order to improve community resilience to natural disasters (Di Capua and Peppoloni 2014; Dolce and Di Bucci 2015; Guzzetti 2015);
- aims to analyze and improve the relationships between the scientific community, decision makers, the mass media, and the public (Di Capua and Peppoloni 2014; Dolce and Di Bucci 2015; Guzzetti 2015; Lambert and McFadden 2013; Liverman et al. 2008);
- promotes the educational, aesthetic, and scientific value of geological heritage and geodiversity in order to improve social awareness of the importance of protecting geological items and outcrops (GA 1975 and 1989) and encourages the development of geoparks (UNESCO 2006) and geo-tourism (Dowling 2010, Allan 2015) as tools to achieve these objectives;
- highlights the value and usefulness of geoscience knowledge in daily life by using disciplines such as medical geology (Selinus et al. 2013) and forensic geosciences (Bergslien 2013);
- encourages inclusive policies in the geoscience community, particularly regarding women (Holmes and O'Connel 2003, Bell et al. 2003), visible minorities, and geoscientists with disabilities (Asher 2001).

Geoscientists often claim social roles and spaces of communication in society as their right. Nevertheless, they also have a duty to consider ethical issues as the basis of their professional training and overcome anachronistic and damaging disciplinary divisions (Guzzetti 2015). In this manner they will gain authority as well as trust and respect of other components of society.

II. GEOETHICS AND GEOSCIENTISTS

a. Role and responsibility of geoscientists

The study of the many interrelationships that exist within the Earth systems requires the integration of multi-disciplinary approaches and different skills and methods of investigation. In fact, modern science requires that professional scientists be able to work independently and in multi-disciplinary teams.

The role of the geoscientist is essential in the analysis of phenomena and processes and in their integrated and dynamic understanding, as well as in their management and supervision. Their skills allow them to frame natural phenomena and choose the more appropriate interventions within a given natural context and time dimension. Qualities such as precision, accuracy, reliability, punctuality, attention, self-sacrifice, self-denial, patience, enthusiasm, and intuitiveness are some prerequisites for a qualified geoscientist. Nevertheless, geoscientists can be responsible and aware of the ethical, social and cultural implications of their activities only if they also possess additional virtues such as integrity, honesty, transparency, collaborative attitude, humility, and respect for the values, ideas, and scientific hypotheses of others.

Responsible geoscientists understand the importance of correctly communicating the results of their research and appreciate the importance of transferring their scientific knowledge to society. Sharing data and ideas with colleagues, decision makers, and citizens can open the way to valuable and functional relationships that will benefit the planet and humankind. Geoethics offers this possibility.

The geoscientist is the core of an ethical reference system in which individual, professional, social, and environmental values coexist. In fact, geoethics refers to the self-behavior of a geoscientist as well as to his or her behavior towards colleagues, with regard to research integrity and professionalism; but it includes also aspects of responsibility towards society and the environment.

Matteucci et al. (2014) are confident that the introduction of an ethical oath for geoscientists, the "Geoethical Promise," which is akin to the oath for physicians, could help develop a binding awareness of a geoscientist's professional and social responsibilities. These responsibilities arise from the possession of specific knowledge that has clear social implications and involves moral obligations to serve society to the best of one’s own scientific and technological potential. The ethical obligation of modern geoscientists is based on fundamental values that should guide their activity, such as the responsibility to ensure excellence in science and in the search for truth, the promotion of sustainability, and the transfer of knowledge to colleagues and society, as a life-long commitment.

b. Geoethics and research

Honest and open collaboration among colleagues is a pre-requisite for building modern scientific, technological, and professional networks able to address the complexity of an interdependent world.

Geoscientists often work in teams, where they manage large amounts of data. Their careers are often certified and evaluated on the basis of the number and quality of publications they produce. Personal ambitions may collide with increasing competition between professional groups, which can lead to unethical behavior (Mayer 2015) or conflicts of interest (Oreskes 2015; Tollefson 2015). Inappropriate attitudes towards colleagues, falsification and concealment of data and results, and conflict of interest are just some of the unethical actions that may arise during research and professional activities and that will undermine both the general trust in science and technology and the potential to attain real progress for society.

For these reasons, the scientific community recognizes the importance of identifying tools to promote integrity among its members, to define principles, and to develop responsibilities that will govern the practice of science. Two significant statements have arisen: the Singapore Statement on Research Integrity (2010) and the Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations (2013). As expressed by the authors of the Singapore Statement "The value and benefits of research are vitally dependent on the integrity of research. While there can be and are national and disciplinary differences in the way research is organized and conducted, there are also principles and professional responsibilities that are fundamental to the integrity of research wherever it is undertaken." (http://www.singaporestatement.org/statement.html). The Singapore Statement is a global guide for the responsible conduct of research and lists the following ethical principles and responsibilities: honesty and accountability in all aspects of research; professional courtesy and fairness in collaborative work; and good stewardship of research on behalf of others. These are the cornerstones upon which the research of geoscientists should be based. Even though the Singapore Statement relates specifically to research activity, it contains universal principles that can be followed in all activities conducted by geoscientists, whether they work in the public or the private sector. The Montreal Statement addresses the problems inherent in professional collaborations in more detail, identifying the principles behind a framework that will assure fruitful and transparent collaboration amongst colleagues.

These two documents do not solve all the problems of research misconduct or conflict of interest, but they are useful tools for making scientists aware of their personal behavior and their responsibilities towards their colleagues. Although some in the geoscience community seem to be unaware of the difficulties that can arise from geoethical misconduct, some sensational cases have been well documented in the scientific literature (Mayer 2015) and make even more persuasive the case for considering geoethics carefully in the coming years.

c. Geoethics and professional societies

Training geoscientists to be aware of their professional behavior begins with honor codes in academia during the undergraduate and graduate years and continues into professional practice through membership in professional societies such as the American Geophysical Union (AGU), the European Geophysical Union (EGU), the Geological Society of America (GSA), and numerous other geoscience societies as well as the American Association for the Advancement of Science (AAAS). In order to find codes relating to personal conduct, organizational conduct, and conduct toward society and the environment, one must often look at both the codes of conduct and the mission/values/objectives of the professional societies themselves.

Organizations go beyond setting guidelines for individual behavior by encouraging members to examine their relation to society and to the environment. Action in these broader areas requires careful balancing of statements to which we lend our professional credibility and statements that might be misconstrued as political advocacy. In the past, organizations have tended to shy away from strong statements about the relationship of humans with the environment for fear of appearing to take advocacy positions. However, owing to the pressing need for action to preserve the environment, more and more societies have adopted broader statements and have become more adept at avoiding clear advocacy positions.

One example of how a professional society can be guided by ethical considerations is the statement regarding climate change on March 18, 2014, by AAAS:

"As scientists it is not our role to tell people what they should do or must believe about the rising threat of climate change. But we consider it to be our responsibility as professionals to ensure, to the best of our ability, that people understand what we know: human-caused climate change is happening, we face risks of abrupt, unpredictable and potentially irreversible changes, and responding now will lower the risk and cost of taking action."

In issuing statements like this, professional societies are guided by both their codes of ethics/conduct and their organizational values/objectives.

As a second example, in its Strategic Objectives, AGU states its desires to:

- increase awareness of the importance of Earth and space science issues for nonscience audiences;
- increase effectiveness and recognition of AGU among decision-makers as an authoritative source of integrated, interdisciplinary Earth and space science information;

- increase awareness of the reality and consequences of global climate change among scientists and the public;
- increase the role of Earth sciences in informing policy and mitigating impacts of natural disasters;
- raise awareness of natural resource limitations and increase the application of (AGU) Earth sciences in developing solutions for the sustainability of the planet.

As a final example, the American Geosciences Institute (AGI) is the umbrella organization for 50 American professional societies such as AGU and GSA. In an effort to summarize codes of conduct, AGI recently revised it ethical guidelines (Boland and Mogk 2016, this volume) to include the following:

"In day-to-day activities geoscientists should:

- Be honest.
- Act responsibly and with integrity, acknowledge limitations to knowledge and understanding, and be accountable for their errors.
- Present professional work and reports without falsification or fabrication of data, misleading statements, or omission of relevant facts.
- Distinguish facts and observations from interpretations.
- Accurately cite authorship, acknowledge the contributions of others, and not plagiarize.
- Disclose and act appropriately on real or perceived conflicts of interest.
- Continue professional development and growth.
- Encourage and assist in the development of a safe, diverse, and inclusive workforce.
- Treat colleagues, students, employees, and the public with respect.
- Keep privileged information confidential, except when doing so constitutes a threat to public health, safety, or welfare.

As members of a professional and scientific community, geoscientists should:

- Promote greater understanding of the geosciences by other technical groups, students, the general public, news media, and policy makers through effective communication and education.
- Conduct their work recognizing the complexities and uncertainties of the Earth system.
- Sample responsibly so that materials and sites are preserved for future study.

- Document and archive data and data products using best practices in data management, and share data promptly for use by the geoscience community.
- Use their technical knowledge and skills to protect public health, safety, and welfare, and enhance the sustainability of society.
- Responsibly inform the public about natural resources, hazards, and other geoscience phenomena with clarity and accuracy.
- Support responsible stewardship through an improved understanding and interpretation of the Earth, and by communicating known and potential impacts of human activities and natural processes".

Such guidelines for personal and organizational ethical behavior are meant to help geoscientists retain professional integrity as they interact with society and the environment.

d. The meaning of serving society

In a landmark Presidential Address to the Geological Society of America in 1992, outgoing GSA President E-an Zen contemplated the role of geologists in society (Zen 1993). First, he addressed the need to "relate scientific knowledge to society's sense of value - what is right, what is wrong, what is important…" He suggested that one of the first actions required was to show people that scientists are not the TV caricatures that they often were, and still are, portrayed as, but rather are normal human beings, sharing the concerns, impulses, and other human traits common to our species. Stressing that science is a public enterprise with public funding, he urged that scientists dialogue with the public, cultivating shared values as well as shared interests by focusing on the common stake that we have in the future.

One of the major ethical issues faced by geoscientists is finding their role in the context of ever increasing population pressures on the planet. To illustrate how these challenges have grown, consider that in 1992, when Zen gave his speech, the population of the planet was 5.448 billion. At the time of the writing of this manuscript (November 2016), the population is 7.355 billion. In 23 years, the population of the planet has increased by nearly 1,677,000,000 people, a 31% increase. Alone among all scientists, geoscientists and geoengineers are the ones who explore, find, and extract needed resources. Extraction of these resources is an activity that often damages the environment, more so in the past and less so today with the adoption of more ethical practices. Yet, along with ecologists, geoscientists are also uniquely qualified to help protect the environment. Geoscientists and society face many ethical challenges as we strive to provide resources for the present, conserve resources for future generations, and preserve the environment for other species if not for their own intrinsic value, then because a thriving ecosystem is essential for the survival of *Homo sapiens.* As individual geoscientists acting within our narrow mandate to explore the Earth, we can contribute much to the body of knowledge about how the planet works. However, in order to serve society, we must interface with those who make decisions on how our body of geo-knowledge is used. Treading along this interface is not easy, and the slightest slip, or appearance of slip, can cost the geoscientist his or her credibility.

An interesting and successful experiment in California may set a precedent for how this balancing act can be accomplished. A partnership was developed between the U.S. Geological Survey (USGS - a Federal agency) and the office of the Mayor of the City of Los Angeles to explore preparation for and response to the inevitable large earthquake that will impact the city. A prominent USGS seismologist, Dr. Lucy Jones, was assigned by her agency to work in the office of Mayor Eric Garcetti. Jones perceived her job as explaining the science, and the consequences of taking action or of not taking action. But she always stopped short of getting involved in the decision-making process regarding actions. In this way, she retained her credibility as a scientist while gaining the ears and respect of the decision-makers in Los Angeles. Mayor Garcetti mandated that Jones should put together recommendations on building resilience to earthquake damage.

The collaboration between the USGS and the City of Los Angeles resulted in a survey to determine which buildings are at risk. Among those at risk, two major categories were defined and studied. The first, the so-called "soft-first-story" buildings that were typically built before 1980 when earthquake reinforcement became mandatory, are most at risk. These structures characterize a particular style of Los Angeles apartment building, typically made of wood, in which the base level is smaller than upper levels in order to allow protected parking spaces at street level. It was recommended that mandatory retrofits be done for these buildings within 5 years. Longer time scales are proposed for the second category: concrete structures for which the required work is more complicated and expensive and for which tenants will have to be evacuated during retrofitting. Recommendations were also made for reinforcing water systems and their backups, parts of which cross active faults, so that water pressure would be maintained for fighting the fires that will inevitably break out during earthquakes.

On October 9, 2015, the Mayor's Office announced that the building retrofit ordinance passed the City Council with unanimous support and the Mayor signed it into law (http://www.lamayor.org/mayor_garcetti_signs_historic_earthquake_retrofit_measure_into_law_ensures_safety_for_thousands_of_angelenos).

Interaction with decision-makers is but one way in which geoscientists can serve society. Another way is in the broad area of education. Geosciences are seriously underrepresented in our science curricula. We can, and should, lobby for our fair share of the curriculum and then provide a supply of talented teachers so that future citizens and decision-makers are aware not only of the resources of the planet, but also of the constraints and limitations of the planet which we inhabit.

III. THE GEOETHICAL APPROACH TO GLOBAL ISSUES

a. Climate change

Many geoscientists have documented evidence for short and long periods of shifting global climate. In the past, much of this research focused on covering the billions of years of Earth history preceding the appearance of humans. For years, the discipline of geosciences dominated climate change research, given the defining attributes of climate change and the boundary conditions needed to document time-based fluctuations. What is studied, where data are preserved, how they are collected, and the underlying focus required to look at issues through time made geosciences ideally predisposed for such study. As the study of climate change shifted from the distant past to those changes that have occurred during the last few centuries, however, geosciences were displaced by other disciplines: astronomy, biology, physics, chemistry and mathematics/computer sciences. Geoscientists appeared to become lost in the transition once the link between anthropogenic input and changing climate was proposed. One can only speculate on what caused geoscientists' initial reluctance to enter the field of anthropogenic influences on changing climates.

Only in the last few years have geoscientists once again sought to reaffirm the importance and relevance of their data, knowledge, and skills with regard to this often contentious but always relevant issue (see IPCC 2014 contents). Parameters associated with climate are generally viewed through unique components within the atmosphere, biosphere, cryosphere, hydrosphere, and lithosphere. Each of these components shares attributes, characteristics, outputs, and products that may be well preserved directly and indirectly in the sediment/rock record. Consequently, geoscientists should play a leading role in influencing the scope, direction, pace, and reliability of information gleaned, studied, analyzed, and interpreted in climate change research. Plate tectonics, solar outputs, ocean variability, carbon/oxygen shifts, temperature modeling, biological extinctions/evolution, sea-level fluctuations, glacier advances/retreats, and so on are but a few of the topics of relevance to modern-day climate change studies to which geosciences can and do contribute significant skills and knowledge.

"Climate change" is now firmly entrenched in the culture of contentious topics, heated debates, political awkwardness, public confusion, and, regrettably, scrutiny of scientific ethics. Geoscientists, like many others from related disciplines involved in climate studies, are held to higher standards of accountability, especially when one considers the great chasm that exists between climate change "skeptics" and "proponents." And when real or presumed inappropriate actions attract media attention, the end result takes on a life of its own. For instance, a few years ago, several thousand personal e-mail messages exchanged between International Panel on Climate Change (IPCC) scientists were "leaked" to the public social network, sparking years of arguments and accusations that focused on conspiracy and data manipulation, political agendas, unprofessional practices, and poor judgement by some climate scholars. This so-called "Climategate" scandal proved to be a difficult hurdle for the IPCC to overcome and detracted from the underlying message of this influential body of researchers. Few believed that information was actually being fabricated by the accused scientists in question, but the perception that respected scientists were not bound to follow the highest ethical standards lingers. The media scandal provided a sobering lesson to geoscientists. One must tacitly adhere to the formalities of the scientific method, welcome discourse and disagreement, adopt transparency of practice, and at all costs remain disconnected from judgments in conclusions.

The role of the geoscientist is clearly to provide accurate information, unbiased interpretation, and fact-based replies to queries. Confusion arises when personal opinions and beliefs merge with our scientific practice. Scientific skepticism is fundamental to our success in performing good science, and, indeed, questioning all our beliefs underlies the success of the science. However, skepticism should not be confused with obstinacy and denial. Distinguishing healthy skepticism from unethically motivated denial is still a barrier to successfully communicating the valuable information managed by the climate change community. The challenges facing geoscientists in climate change research should diminish appreciably when they are working firmly within the constructs of a geoethical paradigm.

Finally, as noted elsewhere in this paper, the role of professional geoscience organizations, learned societies, and other bodies is paramount in adhering to the principles of disciplinary geoethics. Easily accessible and widely distributed commentary in the form of "position papers" is a fundamental obligation of the geosciences. In the case of climate change discussions, groups such as the Geological Society of America (http://www.geosociety.org/positions/pos10_climate.pdf), Geological Society of London (https://www.geolsoc.org.uk/climaterecord) and the Association of Professional Engineers and

Geoscientists of British Columbia (https://apeg.bc.ca/getmedia/a39ff60e-80a1-4750-b6a5-9ddc1d75248a/APEGBC-Climate-Change-Position-Paper.pdf.aspx) have been instrumental in leading the way for such socially beneficial interaction through their own position papers.

b. Georisks

Ensuring the safety of individuals and society is a fundamental obligation of those geoscientists involved in the study of geohazards and georisks. The efficacy with which this fundamental obligation is being met can best be assessed by looking at the annual global synopsis by the Munich Re Group on the state of affairs for hazards, risks, and disasters in the preceding year. In their 2015 assessment, they confirm that the loss of lives due to natural disasters around the world in 2014 was the second lowest since 1980 (Munich Re 2015). This conforms to an overall trend in lowering the death rates from natural catastrophes in both developed and developing nations. Better informed individuals and communities, more resilient land-use practices, higher standard building codes, enhanced emergency response measures, and so on have collectively contributed to reducing the risks and impacts of many natural disasters. In this regard, geoscientists have performed well through their contributions to studying natural hazards and risk reduction through collaborative interdisciplinary work, effective community engagements, and inclusive reliance on local, regional and national government forces (Bobrowsky 2013).

The flip side of natural catastrophes and disasters is that any human losses are still an unacceptable consequence. Moreover, the clear trend in economic losses during the past few decades has been inversely proportional to the human losses. Costs from natural catastrophes continue to rise at alarming rates. What used to be measured in millions of dollars is now routinely measured in billions of dollars. One pervasive observation remains: human losses are more often borne by developing nations, whereas the economic losses are more often borne by developed nations.

In the past, the question of geoethics as related to georisks was rarely considered, in contrast to the more common queries surrounding geoethics as related to the resource sector for instance. Trust and complacency in the geoscience community have been tested many times - for instance, the 1985 eruption of Nevado del Ruiz volcano in Colombia, which pitted volcanologists against government officials and resulted in the death of some 23,000 individuals after warnings by the professionals were dismissed (Bruce 2001). In this case, although the opinions of the geoscientific community were ultimately proven to be correct, there were no long- term changes in the level of enhanced trust and respect of opinion accorded to geoscientists. However, after the cataclysmic 1991 eruption of Mount

Pinatubo in the Philippines, the IAVCEI Committee for Crisis Protocols, published a professional code of conduct for scientists during volcanic crises (Newhall et al., 1999).

The significance of ethics in geosciences took a dramatic shift in the eyes of the world following an earthquake in central Italy near L'Aquila that contributed to the death of some 300 people. Ironically, the mortality associated with this event was only 1/100th that of the 1985 Colombian disaster and yet the long-term impact for the profession was several orders of magnitude greater for political and judicial reasons. In 1985, no individual or group of individuals was held accountable for the death of thousands in Colombia. But in 2009, the Italian political and judicial systems held that the group of scientists responsible for overseeing earthquake risk in the area failed in its duty (Hall 2011). The subsequent charge of criminal negligence rocked the geoscientific community. Geoscientists around the world were more concerned with the misguided belief that practitioners are expected to predict hazardous events than they would have been with issues of inappropriate guidance or poor communications (Cocco et al. 2015).

Geoscientific work in hazards and risk is less vulnerable to conflicts of interest, personal bias, contrasting values, and lack of interdisciplinarity. Problems arise instead over matters of judgment, decisions, and communication. Risk reduction is normally addressed through well-established protocols based on quantitative assessments (Jordan et al. 2014; Newhall et al. 1999). Because the communication of risk is necessarily transformed into qualitative descriptors upon which life-and-death decisions are often made, it is here that practitioners need the greatest reflection within a functioning paradigm of geoethical philosophy.

c. Natural resources

As far back as the Paleolithic, early hominids relied on a rudimentary geological knowledge to use unique formations and landscapes for protection and habitation (rock shelters), specialized mineral extraction (for ochres/stains/paints essential for cave murals and art), and the unique petrological characteristics of certain rocks (such as basalt, chalcedony, obsidian, and flint) proven to be best suited for production of tools required to hunt game. Since that time, the reliance of modern societies on geosciences as a resource-based discipline has grown exponentially. Today's geoscientific practitioners are the backbone of multibillion-dollar economies centered on an unprecedented global demand for oil, gas, minerals, and water. Geoscientists by definition play the pivotal role of ensuring that society has sustained and reliable access to essential resources. The ability to properly search for, successfully locate, economically extract, and reliably provide an incredibly diverse suite of basic natural resources for human consumption is often overlooked by most outside the geoscientific community itself.

Questions concerning ethics in the resource industry are considerable because it provides a perfect storm of competing obligations, objectives, and goals. In many cases, an individual geoscientist need not be concerned about geoethical issues because he or she works in situations far removed from such interactions; but in other cases, opportunities for unethical actions appear almost unavoidable. Responsible behavior quickly enters a grey area when geoscientists are expected to work in an environment that limits freedom of choice. Company practices that focus on profits dictate operational policy and drive workforce performance, placing a burden on geoscientists. When compromises become additive, individuals are soon complicit in actions that contravene what is best for the environment or society in general. Those dealing in geologic commodities are particularly prone to the pressures of maintaining ethical practices. The inherent nature of supply and demand markets for natural resources such as coal, gas, oil, copper, iron ore, and rare-earth elements centers on prices and profits. In the frenzy to reach profits along the food chain of the resource industry, the altruistic goal of providing necessary resources for societal benefit can quickly become lost.

A turning point regarding geoethics in the resource industry occurred in 1997 with the collapse of the Canadian company Bre-X Minerals Ltd. A few years earlier, geologist Michael de Guzman announced the discovery of gold in the jungles of Borneo (Indonesia). Although the site contained no gold, de Guzman systematically manipulated assays by salting core samples. Geologists, stock analysts, and investors around the world were deceived and helped drive the penny stock shares to an extraordinary peak of $286 CDN. Once the fraudulent actions of de Guzman were exposed, the value of company shares completely collapsed, generating one of the most prominent mining scandals of all time. As a consequence of this event, the push to regulate the professional practice of geology was initiated (Andrews 2014).

Self-regulation by technical and professional bodies in the resource sector works effectively to improve the standards of performance within the geoscience industry. For example, organizations such as the Prospectors and Developers Association of Canada (PDAC) help develop and promote high standards of practice, values, and ethics to their community of members. The mission of PDAC is clear: "The PDAC exists to promote a responsible, vibrant and sustainable Canadian mineral exploration and development sector. The PDAC encourages leading practices in technical, environmental, safety and social performance in Canada and internationally." In March 2007, the PDAC developed a special publication entitled "Sustainable Development and Corporate Social

Responsibility [CSR]: Tools, Codes and Standards for the Mineral Exploration Industry" (http://www.pdac.ca/pdf-viewer?doc=/docs/default-source/public-affairs/csr-sustainable-development.pdf). This 20-page document summarizes 36 national and international CSR codes, standards, and tools which provide best practice examples for industry practitioners to adopt. Moreover, the PDAC addresses other key geoethical issues, including land access and land-use planning, Aboriginal rights and engagement, and revenue transparency and promotes federal legislations such as the Government of Canada's Extractive Sector Transparency Measures Act. The PDAC's actions provide a good example of how geoethics can be intimately woven into the fabric of an entire resource industry such as mining.

Geological resources are extremely difficult to extract. The impact on the environment can be substantial but not always permanently damaging. Minimizing impacts, reducing risks, and adopting strong mitigation and remediation practices have become standard actions for most practitioners in the resource industry. Thousands of documents now exist to regulate or guide resource industries in various phases of development from exploration to construction to closure. For instance, in Alberta, Canada, the Alberta Energy Regulator (AER) has jurisdictional responsibility for managing water and the environment with respect to energy resource activities in the province. Documents such as the 141-page "Best Management Practices for Pipeline Construction in Native Prairie Environments" help regulate the energy sector in that province to function according to the highest standards (https://www.aer.ca/documents/applications/BestManagementPracticesPipeline.pdf). Another Canadian example is the "Guide for Surface Coal Mine Reclamation Plans" developed and overseen by the Nova Scotia government in eastern Canada (https://www.novascotia.ca/nse/ea/docs/EA.Guide-SurfaceCoalMineReclamation.pdf). The guide covers everything from site monitoring and maintenance to acid rock drainage control and public safety.

Geosciences play a significant role in the management of water resources. Conflicts continue to increase over access to water, and predictions for the future suggest that such conflicts will increase in the face of more frequent droughts, political border disputes, drying reservoirs, and restrictions to subsurface aquifers. The significance of this resource has finally been recognized at the highest levels of bureaucracy. In 2010, the United Nations General Assembly recognized that access to clean drinking water is a basic human right through Resolution 64/292 (http://www.un.org/es/comun/docs/?symbol=A/RES/64/292&lang=E). Geoscientists involved in water resources will be increasingly challenged to deal with conflicting economic, social, cultural, and political pressures and as a consequence will be burdened with dilemmas regarding acceptable standards of practice, adhering to high values, and adopting ethical decisions.

d. Engineering Geology

"Engineering Geology is the science devoted to the investigation, study and solution of the engineering and environmental problems which may arise as the result of the interaction between geology and the works and activities of man as well as to the prediction and of the development of measures for prevention or remediation of geological hazards" (IAEG 1992). This definition encompasses both the microethical domain of individual projects and the macroethical domain of engineering geology's relationship with society, providing the expertise needed to address global issues of our changing planetary ecosystem (Heckert 2005).

How does an engineering geologist maintain an ethical practice? A typical engineering geologist might answer, "Just do a good job." "Be honest." "Always meet the legal requirements of the job." In the United States they might refer to the ethical codes of the Association of Environmental and Engineering Geologists (AEG), the American Institute of Professional Geologists (AIPG 2003), and the Professional Practice Handbook of the AEG (Hoose 1993). Canadian engineering geologists would refer to Canadian Professional Engineering and Geoscience, Practice and Ethics (Andrews 2014), which is studied prior to their Professional Practice Exam.

Focus on project-scale issues is appropriate and necessary for most of the work of a typical engineering geologist, who often works as part of a team lead by engineers. Their goal is to complete the project on time and within the budget. The limited role of the geologist on such a team is to supply quantitative geological data and useful geomorphic information to the engineers for their subsequent design work. In this tightly constrained scenario, "Do a good, honest job that meets all code requirements" might be an adequate statement portraying the nominal microethics of an average engineering geologist. However, in some cases "just meeting the codes" might be insufficient to protect public safety and welfare.

We assert that engineering geologists have a range of responsibilities in service to the public that is broader than the legal responsibility to meet code requirements. Any project will have its intended product (for example, a flood control dam built in an area that is prone to flooding during storms), but that project might have broader effects that might adversely impact other people or infrastructure (McPhee 1989). The project may be entirely legal yet could place innocent people in danger. The result of a project may persist beyond the lifetimes of those who work on it and might have adverse effects that will take decades to become evident. A professional engineering geologist needs to be an advocate for the public as well as an informed steward of the Earth who considers the broader impacts and long-term effects of a project.

We assert that the ultimate client of any engineering geologist is society and that engineering geologists share in an engineer's canonical responsibility to "hold paramount the safety, health, and welfare of the public and [to] strive to comply with the principles of sustainable development" (ASCE 2006; Cronin 1991, 1993). If engineering geologists fail to act ethically as responsible scientists in the public interest, their contributions "will not be sought or valued by society" (Slosson et al. 1991).

Engineering geology occupies a vital niche in society, providing essential expertise as society confronts geologic hazards and decides how to mitigate or avoid such hazards. In addition to long-recognized hazards (for example, volcanism, earthquakes, floods, expansive soils, groundwater issues, and landslides), society will have to become more adaptive and resilient in the face of regional and global-scale environmental changes in the decades to come. Examples of likely challenges include persistent droughts, severe storms, more frequent and severe flooding; coastal erosion and retreat due to rising sea levels, and inundation of areas where towns, critical infrastructure, and agricultural resources now exist.

Engineering geologists must understand, accept and act upon their responsibility to help society manage geologic hazards, regardless of whether they are natural or human-induced. Engineering geologists need to maintain their ability to manage microethical issues of day-to-day project-level work. They also need to expand their vision to include the macroethical imperative to help society understand and address sustainably the regional and global challenges it faces. No other group has the training, perspective, and knowledge of Earth's history, processes, materials, and hazards to provide this essential service. Engineering geologists must learn to speak with a voice that society listens to, considers seriously, and values.

e. Geoscience communication

We live in an age of communication. At the dawn of the 19th century, the fastest long-distance communication involved someone riding a horse. We communicated face to face or in writing. Geologic ideas and discoveries were presented in books or in a journal produced by one of the very few scientific/philosophical societies of that era. Today, grammar-school kids in Alabama can engage geoscientists doing research in the Arctic in real time via satellite uplinks and the internet. The worldwide-web and social media makes information - good or bad, unbiased or biased, useful or not - available to anyone who has the means (and the political freedom) to connect.

The proliferation of information sources and the wide range in quality are challenges we all face. A geoscientist working in almost any active field of research is deluged by information. Ease and immediacy of communication can overwhelm us with information while sometimes depriving us of sufficient time to turn information into enduring knowledge. As with many things, this wealth of information is not evenly distributed.

The production and distribution of research papers and other forms of formal scientific communication cost money. The traditional approach has been to assess page charges to authors for publishing their papers and to charge fees to people who would like to read the papers. Subscription-access peer-reviewed scientific communication is a filter that excludes the vast number of people who cannot afford to pay for access. The trend toward open-access and delayed-open-access publication of peer-reviewed scientific work via the web is an enormously positive development that will empower people worldwide. As diversity among scientists increases, it is likely that the range of useful scientific ideas will also increase.

Academic geoscientists are trained to communicate with other scientists at professional meetings and through peer-reviewed scientific literature. Commercial geoscientists are trained to provide their expertise to their internal and external clients, often in confidential reports. The reward systems for geoscientists are based in part on how well we communicate with our specialized technical language. Geoscientists also have a fundamental responsibility to communicate with the rest of the public about geoscience issues, using language that is clear, direct, and understandable by the average young adult. Society paid ahead its investment in geoscientists long ago by building universities and concentrating the resources needed for our specialized technical education. We have a responsibility to report back to society, sharing what we have learned about Earth's history, processes, materials, and hazards.

Geoscientists who possess reliable, unbiased, science-based knowledge are notably absent from the public square, where important matters affecting society are brought forward and discussed. It is of great concern that the public is largely ignorant about some of the greatest challenges that it faces - problems whose solutions will require geoscience expertise, such as water and energy supply, soil conservation, geologic hazards, and supply of industrial minerals. A well-educated geoscientist has a general store of knowledge about Earth that significantly exceeds that of a typical politician or member of the public. That knowledge must be shared with every new generation. It is reasonable to expect any well-educated geoscientist to help the public understand issues such as the basic implications of the depletion (extraction) of potable groundwater, or the general risks associated with living near a fault that can produce magnitude 6+ earthquakes, or why it is not a good idea to live in a "100-year" flood plain, or the hazards of living above a subduction zone or downwind from an active volcano, or the consequences of sea-level rise for coastal communities and low-elevation agricultural fields.

Well-educated geoscientists have the intellectual resources to be of service to the public as it tries to manage a range of important problems. We have an ethical responsibility to provide reliable information to society about Earth. Providing expertise is part of the social compact between geoscientists and the public. The information void that will be created if we shirk our responsibilities to educate society will likely be filled by the uninformed or the inexperienced.

f. Geoeducation

When members of a community act ethically toward one another, public benefits such as peace, justice, and general welfare are more likely to predominate. This common-sense assumption has been around for as long as there has been a written record of moral philosophy - more than two thousand years in the western tradition. We observe, however, that people do not always act ethically toward one another, so how does a community promote the idea that its members should behave ethically? Three steps seem to be necessary. First, ethical behavior should be affirmed by the community as the expected norm. Second, ethical behavior should be taught as well as modeled in both formal and informal educational settings. Third, unethical behavior should be identified as unacceptable, and there should be undesirable consequences for such behavior.

Ethical behavior is essential to science, whose purpose is to develop reliable knowledge about the physical world based on reproducible observation and development of testable explanations. There is no science without honesty, and truth telling is a fundamental ethical virtue. There is an ethical element present in even the most basic scientific observations: I am measuring this carefully using an appropriate standard; I repeat the measurement several times; I assess the uncertainty in my measurements; I report my method, the data, and the uncertainty for others to scrutinize. Even the simplest scientific methodology has as its purpose the discernment of some reproducible fact about the physical world within an inevitable haze of uncertainty. That idea should be conveyed and understood from the first brief lessons about science in primary school onward. Science does not ignore uncertainty - it accepts uncertainty as an essential part of the process. Whether a primary school student grows up to become a scientist or not, it is crucial that he or she understand that the practice of science involves uncertainty. Students will eventually encounter people who are absolutely certain that science is wrong, and they may believe that the Earth is not old, or organisms did not evolve, or that human activity cannot change the global environment. Science, on the other hand, is not in the business of achieving absolute certainty. Science is in the business of framing ideas in a way that they can be tested and falsified. Science is rooted in doubt, uncertainty, and skepticism, and those roots have generated our most reliable knowledge about the physical world. Scientists seek knowledge that withstands the tests of experience and time.

In the geosciences, the imperative to act ethically should be emphasized continuously from the first Earth science module in primary school until a person takes off their field hat, lays down his or her maps and compass, and turns off the laptop for the last time as a practicing geoscientist. It is particularly important that geoethics be infused throughout a novice geoscientist's undergraduate (and graduate) education. (See chapter 7 of this volume for more on teaching geoethics within a university.)

Each of us is ultimately responsible for our own behavior; however, the geoscience community is responsible for promoting ethical behavior among its members and discouraging or penalizing unethical behavior. Ethics should be a constant and primary concern for the entire alphabet soup of scientific and professional groups that serve the geosciences. These communities bear partial responsibility for the continued ethical development of their members. Knowledge of applied geoethics is a requirement of professional certification and licensure for geoscientists in many jurisdictions (for example, AIPG 2003, 2015; Williams 2016 this volume; Andrews 2014). Continuing education in ethics is a common requirement for renewal of professional-practice licenses for geoscientists.

K-12 education (kindergarten/preschool to high school/precollege) in science should introduce all students to the central importance of truth telling, uncertainty, and ethics in science. University geoscience courses should emphasize the ethical practice of our science throughout their curriculum. This effort should be supported by online materials developed by the broader geoscience community to enhance student understanding of geoethics. Post-graduate geoscientists should constantly work to improve their practical understanding of applied ethics and, more importantly, should model ethical professional conduct every day of their careers. They have an ethical responsibility that extends beyond their clients to all of society as we grapple with worldwide challenges related to water, energy, minerals, geologic hazards, and the effects of global change.

g. Protection of geoheritage and geodiversity

The concepts of geodiversity and geoheritage have been informally addressed for centuries by the geosciences but only recently have the terms themselves taken on the need for formality and definition. Notwithstanding a plethora of definitions, "geodiversity is the variety of rocks, minerals, fossils, landforms, sediments, water and soils, together with the natural processes which form and alter them; geoheritage comprises those elements of the Earth's geodiversity that are considered to have significant scientific, educational, cultural or aesthetic value. Geoconservation is actions and measures taken to preserve geodiversity and geoheritage for the future." (https://www.iucn.org/about/work/programmes/gpap_home/gpap_biodiversity/gpap_wcpabiodiv/gpap_geoheritage/).

It is within this realm of research where few issues relating to the negative aspects of geoethics arise and where most characteristically the positive outcomes of geoethics are practiced. The study of geoheritage provides ethical, social, and cultural values of reference for the scientific community and society as a whole. Our efforts in geoconservation provide an example of how the discipline aims to ensure that the "face" of the planet (rocks, landscapes, water, and so on) is adequately protected for future generations. Promoting geoeducation and geosciences to the global society is an important aim that has become increasingly well addressed by those geoscientists who have devoted their practice to geoheritage work.

In the past decade, there has been an explosion in studies, movements, organizations, and societies whose focus covers the full range of geoheritage and geodiversity. Notably at the highest levels of bureaucracy, there is the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas (WCPA) Geoheritage Specialist Group (GSG) that facilitates the conservation and effective management of protected area geoheritage. There is also the International Union of Geological Sciences Geoheritage Task Group (http://geoheritage-iugs.mnhn.fr/index.php?catid=1&blogid=1) that facilitates national and international awareness and understanding of underlying geoheritage concepts. Special interest groups have formed for specific goals such as conservation and preservation, the most notable of which is ProGEO (http://www.progeo.se/), the European Association for the Conservation of the Geological Heritage, whose purpose is "to give Earth-science conservation in Europe a stronger voice, and to act as a forum for the discussion of issues, advising and influencing policy makers."

The Geopark movement is another global phenomenon that has taken on the multidisciplinary roles of geoheritage recognition, conservation, and protection; public awareness and education; cross-border international collaboration; improving the quality of life for local populations through economic stimulus; and a general move towards greater awareness of the importance and diversity of nature. Again at the highest levels of bureaucracy, UNESCO supports the Global Geoparks Network (GGN) by providing formal accreditation to those "parks" that successfully "demonstrate geological heritage of international significance[;] the purpose of a geopark is to explore, develop and celebrate the links between that geological heritage and all other aspects of the area's natural, cultural and intangible heritages" (http://www.globalgeopark.org/index.htm). Regional efforts that complement the GGN include the European Geoparks Network (EGN) and the Asia Pacific Geoparks Network (APGN).

Geoheritage, geodiversity, and geoconservation are concrete expressions of a geoethical vision of the planet: recognizing their importance as a means to restoring an inner connection between humans and the Earth is a fundamental starting point to develop best practices in land management.

h. Sustainability, Resilience and Geoethics

Sustainability and resilience are related. Sustainability is defined in many ways, but the most generally cited definition is that of "sustainable development" from the Bruntland Commission (WCED 1987):

"Sustainable development is the concept that development must meet the needs of the present without compromising the ability of future generations to meet their own needs."

The resilience of a community is its capacity to prepare and plan for, recover from, or successfully adapt to adverse events (hazards), both natural and human-made, in both the short term and the long term.

In many ways, resilience and sustainability have more in common than is evident from these definitions. For example, although not obvious in the definition above, resilience has economic, infrastructure, social, and personal components that include equity in the present and the future, components that are explicit in the definition of sustainable development. Likewise, although not obvious in its definition, sustainability has a component that includes resilience, for a society that is not resilient certainly cannot be sustainable.

The great astronomer Carl Sagan (1934-1996) had much to say about science and ethics and typically had eloquent ways to express himself. Although not using the words sustainability and resilience, for example, in his 1996 book "The Demon Haunted World," he states (p. 291):

"It is the particular task of scientists, I believe, to alert the public to possible dangers, especially those emanating from science or foreseeable through the use of science. Such a mission is, you might say, prophetic. Clearly the warnings need to be judicious and not more flamboyant than the dangers required; but if we must make errors, given the stakes, they should be on the side of safety."

Such warnings are especially difficult for scientists to frame and defend when the dangers lie in the future, not the far future but a near-future perhaps still out of reach of the experience of imagination of most people, as the issues of resilience and sustainability seem to be. It is here, at the interface of science and society on these long-term issues, that many geoethical considerations arise. What needs to be done to build resilience, and how do we prioritize the sequence in which it is done? Who loses and who wins as actions are taken to correct living situations that are not resilient or sustainable, such as settlements on flood plains or in the path of volcanic outbursts or landslides? How do we distribute finite resources amongst the ever-expanding population? What is our obligation to preserve resources for future generations? Who do we compensate for damages from a hazard and how much? How do compensations for damages from a hazard help or impede our ability to reduce their impact in the future?

The leaders in building resilience typically are not and cannot be geologists, unless they abandon their scientific identity and enter the public decision-making arena. Those leaders are decision-makers in a wide variety of fields ranging from engineering, to management, public policy, social services, human geography, economics, sociology, and anthropology. But, we geoscientists argue, they can do their jobs better if they have been exposed to the geosciences in their education and if we can gain their attention and provide relevant information. Generally the information that we provide should not be limited to "the facts and only the facts." Our role must also include formulating realistic scenarios (Albarello 2015) about the consequences of various actions and the consequences of not acting, while always avoiding entering the decision-making process itself in order to retain our credibility.

Much of the work in building resilience and sustainability lies in the domains of the social sciences, economics, and government/NGO efforts at various levels. As an example of the talents needed, in 2013, the U.S. National Academy of Sciences established a large group of experts, the Resilient America Roundtable (http://sites.nationalacademies.org/PGA/resilientamerica/), to examine how American cities and regions can increase their resilience to disasters. The goals of the Roundtable are:

- improve risk communication;
- identify ways to measure community resilience;
- share data and information related to hazards, disasters, risk, and resilience; and

- develop or strengthen partnerships and coalitions within and among communities to build resilience.

A partial list of the agencies to which members of the Roundtable belong illustrates the breadth of input that will bring values and ethical issues to the table:

- The Federal Emergency Management Agency (FEMA);
- Department of Homeland Security (DHS);
- National Oceanic Atmospheric Administration (NOAA);
- Red Cross;
- Federal Insurance and Mitigation Administration (FIMA);
- Koshland Science Museum;
- U.S. Geological Survey (USGS);
- National Association of Counties;
- National Voluntary Organizations Active in Disaster;
- U.S. Chamber of Commerce.

IV. Promoting Geoethics: The International Experience of the IAPG - International Association for Promoting Geoethics

Choosing to study geoscience is the result of a passion for nature, rocks, and landscape and the curiosity about the functioning of Earth systems. Often the life of the geoscientist is considered fascinating. Many young people see in this profession a way to live in accord with their ideals: respect for the environment, protection of the planet, and service to society, particularly to people who have limited access to primary resources such as water and arable land.

Geoscience is a group of disciplines that often appeals to those with a strong framework of ideals rather than to those who want to do a quick search for a job. The teaching of ethics in the geosciences has never been a standard part of university courses but is considered an indispensable element on which to base technical-professional training. Moreover, the need to make frustrating compromises and strong competition in the workplace can push young geoscientists away from the ideals that inspired them at the start of their professional careers. The final result is that the current geoscience community is not sufficiently aware of its cultural potential, of the cultural value of geoscience knowledge, of its role in society, and of its ethical responsibility (Peppoloni and Di Capua 2012).

Promoting Geoethics first needs to involve the geoscience community in the discussion about ethical aspects of the geosciences, in order to rediscover the ideals and values that attracted geoscientists at the beginning of their university studies. Such involvement would permit strengthening the ethical conscience of individuals. Geoscientists more aware of the ethical and social implications of their activities, solutions, and decisions will be better able to transfer not only best practices but also best values to society and to contribute to create a knowledgeable society and a sustainable development for future generations.

a. The birth of the IAPG

During the 34th International Geological Congress in Brisbane (Australia, 5-10 August 2012), the foundation of the IAPG (http://www.geoethics.org/) appeared as a logical and necessary step towards giving geoethics a scientific status and towards enlarging the debate on ethical issues to include a wider number of colleagues with different skills and from different countries. The IAPG was born to stimulate reflection on ethical problems in geoscience research and practice and to persuade the geoscience community to consider seriously the importance of conducting their activities responsibly so as to better serve society. The IAPG is an international, scientific, multidisciplinary community whose primary aim is to create awareness about the application of ethical principles to theoretical and practical aspects of geosciences. In the last few years it has become an important space in which many geoscientists can share opinions, exchange information, and propose new ideas and visions for the future development of geosciences in an ethical and social perspective. Being primarily a scientific association, the IAPG takes responsibility for developing geoethics as a scientific discipline, guided by scientific method and reasoning and trying to avoid self-referential positions and to promote discussion. To this end the following results and products of its activity are fundamental:

- scientific publications under a peer-review process;
- sessions on geoethics at national and international congresses.

These powerful tools enlarge the number of geoscientists involved, encourage the sharing of information, thoughts, and proposals, and develop the mature and strong reflection on geoethics necessary to give it wide visibility, full dignity, and official recognition within the geoscience community.

The year 2012 was a turning point for geoethics. The publication of the first volume on geoethics by the journal "Annals of Geophysics" (Peppoloni and Di Capua 2012) was the start of an intense editorial activity that has lead to significant results (Lollino et al. 2014; Peppoloni and Di Capua 2015; Wyss and Peppoloni 2015). The books and articles published since 2012 can offer many cues for current and future discussion. Although presently these publications do not fully treat issues or exhaust the subject, steps made so far have changed the perception of geoethics and turned it from a movement of opinion into a legitimate scientific discipline.

b. Mission

IAPG statutes state that "Geoethics should become part of the social knowledge and an essential point of reference for every action on the land, waters and atmosphere usage that is taken by stake-holders and decision-makers". The IAPG aims to promote geoethical values through international cooperation, encouraging the involvement and discussion of geoscientists from all over the world. Defining an ethical framework on which to base geological activities is the main IAPG goal, which includes:

- adhering to the scientific method;
- being open to debate and to the comparison with ideas of colleagues, even when very far from our view;
- accepting multidisciplinarity as a fundamental working attitude and organization, as an approach that allows the joining together of different professional skills for seeking and sharing solutions to problems in a complex reality;
- to assure to society a qualified long-term learning; and
- respecting the principles of intellectual honesty and integrity in the research and practice of geosciences and being an example for young geoscientists and society as a whole.

c. Strategies and initiatives

In just a few years, the IAPG has become an international reality, known and appreciated for the significant amount of work it has carried out and the contents that it has developed. The results stem from a clear strategy of action and communication, which has its pillars in the following points:

- Development of geoethics as a scientific discipline: talking about geoethics does not mean building opinions. Rather it means articulating a rational reasoning based on experiences that have been analyzed using the scientific method and are related to issues of interest for the geosciences.
- Building a strong network, capable of developing and supporting itself in time: the spread of new ideas in society is possible if groups of individuals who share a set of values and a vision of the future are formed. The network of the IAPG is an infrastructure capable of developing initiatives, organizing events, creating products, and sharing experience and expertise.
- Realization of partnerships with other national and international organizations to promote initiatives on geoethics widely and promptly, by involving different sectors of the scientific community. The IAPG is affiliated to the International Union of Geological Sciences (IUGS) and is recognized as an International Associate Organization of the American Geosciences Institute (AGI), as an Associate International Society of the Geological Society of America (GSA), and as an Associated Society of the Geological Society of London (GSL). The IAPG recognizes the International Council for Science (ICSU) as the coordinating and representative body for the international organization of science; this link ensures that a political frame of reference is maintained. Finally, the IAPG has agreements of collaboration with the EuroGeoSurveys (EGS), the association that joins the Geological Surveys of Europe, the European Federation of Geologists (EFG), the network of European Professional Organizations of geologists, the American Geophysical Union (AGU), the International Geoscience Education Organisation (IGEO), the Association of Environmental & Engineering Geologists (AEG), and the African Association of Women in Geosciences (AAWG); these links ensure efficacious actions with regard to society.
- Promotion of scientific publications as an essential requirement to strengthen the scientific and educational status of geoethics within the scientific community and to give it dignity in front of all other sciences and humanities. IAPG members have promoted and edited several volumes dedicated to geoethics (Peppoloni and Di Capua 2012; Lollino et al. 2014; Peppoloni and Di Capua 2015; Wyss and Peppoloni 2015), participated in the drafting of the formula of the "Geoethical Promise" (Matteucci et al. 2014), and translated into different languages the Montreal Statement on Research Integrity in Cross Boundary Research Collaborations (Peppoloni 2015). The "Geoethical Promise" (see the paragraph 2) can contribute to strengthening the identity of young geoscientists and improving their awareness of the importance of geoethics as a fundamental base of their work

life in geosciences. The aim of translating the Montreal Statement has been to promote research integrity principles by considering linguistic and cultural differences. This means "to share and recognize common principles and values that belong to mankind as a whole regardless of cultural differences. Furthermore, it means to increase the feeling of concerted nature and unity within the entire scientific community and to promote the enhancement of cultural diversity. Cultural diversity should be an element of union and not of division, through which all the scientists in the world can strengthen their identity and their sense of belonging to the scientific community" (Peppoloni 2015).

- Organization of scientific sessions in national and international conferences to involve colleagues in the discussion on geoethical topics, stimulating their proposals, reflections, and initiatives, and to increase the visibility of geoethics among the issues addressed in scientific assemblies. Therefore, the IAPG has organized sessions at the European Geosciences Union (EGU - General Assembly in 2013 (http://meetingorganizer.copernicus.org/EGU2013/session/11853), 2014 (http://meetingorganizer.copernicus.org/EGU2014/session/14404) and 2015 (http://meetingorganizer.copernicus.org/EGU2015/session/19081), registering in the years an increasing interest and attendance; at the International Association of Engineering Geology and the Environment (IAEG) XII Congress 2014 (http://www.iaeg2014.com/programme/8/160-73-geoethics-and-natural-hazards-communication-education-and-the-science-policy-practice-interface); at the American Geophysical Union (AGU) - Fall Meeting in 2014 (https://agu.confex.com/agu/fm14/webprogrampreliminary/Session2751.html); and at the 2015 Annual Meeting of the Geological Society of America (Session T72 at https://gsa.confex.com/gsa/2015AM/webprogram/Session37724.html). IAPG members give invited lectures and speeches at many other conventions and conferences.
- Disseminating geoethics within the society: this means promoting the themes and reflections on geoethical topics outside the scientific community in order to engage citizens, media, and stake-holders in a new vision of the relationship between mankind and the geosphere. To this end, for example, the Italian section of the IAPG organized two conferences-conversations between a geologist and a philosopher of science at the Science Festival of Genoa in 2013 (http://festival2013.festivalscienza.it/site/home/programma/giorno-per-giorno/26-ottobre/geoetica.html) and 2014 (http://www.festivalscienza.it/site/home/programma-2014/giorno-per-giorno/26-ottobre/quali-rischi-sei-disposto-a-correre.html), one of the most important events of

its kind organized in Europe. The success of such events has shown that the public is attracted by cultural "contaminations" of different knowledge and is not intimidated by the complexity of the topics. Rather, topics such as the defense against natural hazards, geo-resources exploitation, environmental defense, and climate changes are central for a public that is asking for scientifically correct information from scientists. From this perspective, interviews given to the Italian media and a broadcast aired on Radio Austria on May 2015 featuring interviews with IAPG members allowed individuals to speak about geoethics to a large part of the population for the first time (http://oe1.orf.at/programm/404157). The long-term effects of these initiatives cannot be easily assessed, as they are only the first significant steps by geoscientists to culturally affect society.

d. The future

Geoethics is a discipline in full growth and in recent years many ideas have been planted in hopes that they would sprout. The results obtained up to now are encouraging. What, then, are the great challenges for the future of geosciences from a geoethical point of view? And in particular what is the future of geoethics?

- Young geoscientists and the teaching of geoethics.

  Early career geoscientists are the greatest resource for the future of geosciences. They will be the custodians of the technical and scientific knowledge of Earth systems, those who will have to transfer this knowledge to future generations and transmit the social and cultural value of geosciences for the welfare of mankind. They can do this only if the scientific community, beyond the adoption of codes of ethics/conduct, will be able to introduce the teaching of geoethics into the university systems as a fundamental component in the training of a geoscientist. Examples and techniques for teaching geoethics across the geoscience curriculum are discussed in Mogk et al. 2016 this volume. Geoscience is not ethical in itself; it is simply a tool in our hands. It is essential that young geoscientists become aware that doing science also means taking responsibility for communicating the impacts of the geosciences on society and ways that society can benefit from this knowledge. What, why, and how we may teach geoethics to young geoscientists should be clarified. It is our duty to give them strong motivations on why they should act in an ethical way.
- Multiple-disciplinarity and multi-knowledge.

Geosciences operate in cross-boundary areas and are called on to contribute by giving solutions through a multiple disciplinary working method in strong collaboration with other disciplines. The multidisciplinary approach brings together different skills and represents a modern way to manage complex systems like the Earth. It also means that the topics of interest for geoethics are in many cases at the intersection between different disciplines. Discussions on geoethics should be able to integrate reflections from a multi-knowledge perspective, in which geoscientists can dialogue with philosophers, sociologists, economists, biologists, chemists, archaeologists, and other scientists and professionals, being always aware of the specificity and uniqueness of their point of views and skills.

- Geodiversity and cultural diversity.

  A globalized and interconnected world is an irreversible reality. The geoscientist has a cultural education which by its nature is open to global dynamics. The geoscientist knows the impact that local phenomena can have at a global scale and studies the variety of natural environments and the richness of landforms in different places on the Earth. There are no good technical solutions to environmental problems if we do not take into account the geodiversity that characterizes each area of the planet as well as the biodiversity and human cultures and traditions that very often (especially in low-income countries) have been able to preserve and transmit human behaviors in equilibrium with natural dynamics. Practicing geoscience in an ethical way means also to consider geodiversity as an essential substrate for biodiversity and as a fundamental component of the cultural richness of human communities.

- Cultural lobbying.

  Are geoscientists able to have an effect in the discussions that animate the public? On the one hand, geoscientists are called upon to communicate science in cultural and entertainment programs; on the other hand, they often have to deal with georisks communication and can sometimes be legally prosecutable (Albarello 2015, Cocco et al. 2015).

  Geoscience is not perceived as a glamorous science like physics or astronomy, and yet geoscientists have a fundamental role in building a knowledgeable society.

  The geoethics arena may be the space in which we can discuss and share those values that will help to develop a healthier relationship between humankind and the planet.

SUMMARY

Geoethics is an emerging field within the geosciences and more generally within science itself. Freedom, responsibility, multidisciplinarity, service to society, sustainability of the economy, and conservation of Earth systems are the fundamental values of geoethics on which geoscientists can base their ethical duty to act responsibly towards themselves, their colleagues, society, and the planet.

The young history of geoethics is the story of a world vision in which geological knowledge, in the broad sense, is the basis of a new way of thinking and practicing within the geosciences in order to contribute to building a knowledge society and to give a rational, positive and sustainable perspective to future generations. The IAPG - International Association for Promoting Geoethics (http://www.geoethics.org) is promoting this vision and the values that underpin it.

Geosciences have always been interwoven with society, so geoscientists need to be fully aware and understand the broader implications of their work if they want to serve society. The lack of an ethical benchmark can be confusing for the geoscientist and may lead to uncertainty and the inability to take decisions. Ethical reflection and awareness should be encouraged and developed in the early years of university and not left solely to later personal initiative.

A globalized world such as the one we now live in offers great opportunities for development, but at the same time our achievements may endanger the very life of our communities. The implications of an unweighted exploitation of georesources, the effects of climate change, the repercussions of non-sustainable energy policies, and a land management practice that is not respectful of natural dynamics could have negative consequences that are unpredictable in the long term.

An ethical conscience can guide geoscientists to respond in a more effective and sustainable way to the needs of society and environment. It is therefore necessary that the development of the technical and scientific possibilities of geosciences be accompanied by an equal development of an ethical conscience. Ethical reflection can prevent errors in evaluating future consequences when sciences and technologies are applied irresponsibly and not enlightened by wisdom and foresight. Geoethics is an orientation tool for geoscientists, able to provide them with the ethical dimension of their actions. A deep bond unites environmental protection and the development of human communities. In coming years, geoscientists must be able to face the enormous challenge of reconciling geoethical values with the practice of geosciences. With this aim in mind geoscientists must be able to function without making compromises in their work, undertake the pursuit of the common good, and ensure the right balance between sustainable living conditions while respecting Earth processes.

ACKNOWLEDGMENTS

Susan W. Kieffer was partially funded by the Charles R. Walgreen, Jr., Chair at the University of Illinois.

REFERENCES

AGI (2015). AGI Guidelines for Ethical Professional Conduct. AGI - American Geosciences Institute, http://www.americangeosciences.org/sites/default/files/AGI%20Guidelines%20for%20Ethical%20Professional%20Conduct%202015.pdf (accessed 25 June 2015).

AIPG (2003). Code of ethics, American Institute of Professional Geologists, http://www.aipg.org/about/ethics.htm (accessed 25 June 2015).

AIPG (2015). Professional certification, American Institute of Professional Geologists, http://www.aipg.org/about/index.htm (accessed 25 June 2015).

Albarello D. (2015). Communicating uncertainty: managing the inherent probabilistic character of hazard estimates. In: Peppoloni S. and Di Capua S. (Eds.). Geoethics: the Role and Responsibility of Geoscientists. Geological Society, London, Special Publications, 419, http://sp.lyellcollection.org/online-first/419 (accessed 25 June 2015).

Allan M. (2015). Geotourism: an opportunity to enhance geoethics and boost geoheritage appreciation. In: Peppoloni S. and Di Capua S. (Eds.). Geoethics: the Role and Responsibility of Geoscientists. Geological Society, London, Special Publications, 419, http://sp.lyellcollection.org/online-first/419 (accessed 25 June 2015).

Andrews G.C. (2014). Canadian Professional Engineering and Geoscience Practice and Ethics [5th edition], Nelson Education, Toronto, Canada.

ASBOG (2015). Task analysis survey 2015: A study of the practice of geology in the United States and Canada, National Association of State Boards of Geology, http://www.asbog.org (accessed 25 June 2015).

ASCE (2006). ASCE Code of Ethics, American Society of Civil Engineers, http://content.asce.org/ethics/policies.html (accessed 25 June 2015).

Asher P. (2001). Teaching an introductory physical geology course to a student with visual impairment. Journal of Geoscience Education, v.49, n.2, p. 166-169.

Bell R.E., Kastens K.A., Cane M., Muller R.B., Mutter J.C. and Pfirman S. (2003). Righting the balance: Gender diversity in the geosciences. Eos - Transactions American Geophysical Union, Vol. 84, Issue 31, p. 292, doi: 10.1029/2003EO310005.

Bergslien, E. (2012). An Introduction to Forensic Geoscience. Wiley-Blackwell, 514 pages.

Bobrowsky, P.T. (2013). Encyclopedia of Natural Hazards. Springer, 1135 pages.

Bohle M. (2015). Geoethics: from "Blind Spot" to "Common Good.". Blog of the International Association for Promoting Geoethics, http://iapgeoethics.blogspot.it/2015/06/geoethics-from-blind-spot-to-common-good.html (accessed 23 June 2015)

Boland M.A. and Mogk D. (this volume). The American Geosciences Institute Guidelines for Ethical Professional Conduct, in Gundersen, L.C. (ed) Scientific Integrity and Ethics: With Application to the Geosciences. Wiley.

Bruce, V. (2001). No Apparent Danger: The True Story of Volcanic Disaster at Galeras and Nevado del Ruiz. Harper, 256 pages.

Cervato C. and Frodeman R. (2012). The significance of geologic time: Cultural, educational, and economic frameworks. Geological Society of America Special Papers 486, 19-27, doi: 10.1130/2012.2486(03).

Choi B.C. and Pak A.W. (2006). Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. Clin. Invest. Med., 29(6), 351-64.

Cocco M., Cultrera G., Amato A., Braun T., Cerase A., Margheriti L., Bonaccorso A., Demartin M., De Martini P.M., Galadini F., Meletti C., Nostro C., Pacor F., Pantosti D., Pondrelli S., Quareni F. and Todesco M. (2015). The L'Aquila trial. In: Peppoloni S. and Di Capua S. (Eds.). Geoethics: the Role and Responsibility of Geoscientists. Geological Society, London, Special Publications, 419, http://sp.lyellcollection.org/online-first/419 (accessed 25 June 2015).

Cronin V.S. (1991). Engineering geology must be dominated by a public-safety-based ethic [abs], Geol. Soc. Am., Abs. with Prog., 23(5), A41.

Cronin V.S. (1992). On the seismic activity of the Malibu Coast Fault Zone, and other ethical problems in engineering geoscience. Geological Society of America, Abstracts with Programs, v. 24, no. 7, p. A284.

Cronin V.S. (1993). A perspective on professional ethics in engineering geosciences. In: Hoose S.N. (Ed.). Proceedings of Symposium on Ethical Considerations in the Environmental Practice of Engineering Geology and Hydrogeology, Association of Engineering Geologists National Meeting, San Antonio, Texas.

Crutzen P.J. (2002). Geology of mankind. Nature, 415, 23.

Devall B. and Sessions G. (1985). Deep Ecology: Living As If Nature Mattered. Gibbs M. Smith, Salt Lake City, ISBN 0-87905-247-3.

Di Capua G. and Peppoloni S. (2014). Geoethical aspects in the natural hazards management. In: Lollino G., Arattano M., Giardino M., Oliveira R., Peppoloni S. (Eds.). Engineering Geology for Society and Territory - Volume 7: Education, Professional Ethics and Public Recognition of Engineering Geology. XVII, 274 p., Springer.

Dolce M. and Di Bucci D. (2015). Risk Management: Roles and Responsibilities in the Decision-making Process. In: Wyss M. and Peppoloni S. (Eds.). Geoethics: Ethical challenges and case studies in Earth science. Elsevier, pp. 450, Waltham, Massachusetts, ISBN 978-0-12-799935-7.

Dowling R. K. (2010). Geotourism's global growth. Geoheritage, 3, 1, 1-13, 10.1007/s12371-010-0024-7.

Ellis E.C. and Haff P.K. (2009). Earth science in the Anthropocene: new epoch, new paradigm, new responsibilities. EOS Trans. 90 (49), 473.

Frodeman R. (1995). Geological reasoning: Geology as an interpretive and historical science. Geological Society of America Bulletin, 107, 960-968, doi 10.1130/0016-7606.

Frodeman R. and Baker V. (2000). Earth matters: the earth sciences, philosophy, and the claims of community. Prentice Hall, p. 209, ISBN 978-0-13-011996-4.

GA (1975). Geological Fieldwork Code. Geologists' Association, London, http://www.geologistsassociation.org.uk/downloads/Code%20of%20conduct/Code%20for%20fieldwork%20combined.pdf (accessed 25 June 2015).

GA (2011). A Code of Conduct for Rock Coring. Scottish National Heritage & the Geologists' Association London, http://www.geologistsassociation.org.uk/downloads/Code%20of%20conduct/GARockCoringGuide.pdf (accessed 25 June 2015).

GSL (2014). Geology for society. A report by the Geological Society of London. http://www.geolsoc.org.uk/geology-for-society (accessed 25 June 2015).

Guzzetti F. (2015). Forecasting natural hazards, performance of scientists, ethics, and the need for transparency. Toxicological & Environmental Chemistry, doi: 10.1080/02772248.2015.1030664.

Hall, S. (2011). Scientists on trial: At Fault? Nature, 477, 264-269.

Herkert, J.R. (2005). Ways of thinking about and teaching ethical problem solving -- microethics and macroethics in engineering. Science and Engineering Ethics, 11(3), 373-385.

Holmes M.A. and O'Connel S. (2003). Where Are the Women Geoscience Professors? Papers in the Earth and Atmospheric Sciences, Paper 86, http://digitalcommons.unl.edu/geosciencefacpub/86 (accessed 25 June 2015).

Hoose S.N. (1993). Professional Practice Handbook [3rd edition], Association of Engineering Geologists, Special Publication No. 5.

IAEG (1992). Statutes Article 2, The definition of Engineering Geology, lnternational Association for Engineering Geology and the Environment, http://150.145.48.31/iaeginfo/wp-content/uploads/documents/IAEG Statutes.pdf (accessed 25 June 2015).

IAPG (2012). Constitution of the International Association for Promoting Geoethics. http://www.geoethics.org/constitution.html (accessed 25 June 2015).

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pages.

Jordan T.H., Marzocchi W., Michael A.J, Gerstenberger M.C. (2014). Operational Earthquake Forecasting Can Enhance Earthquake Preparedness. Seismological Research Letters, 85(5), 955-959. DOI:10.1785/0220140143.

Lambert I., Durrheim R., Godoy M., Kota M., Leahy P., Ludden J., Nickless E., Oberhaensli R., Anjian W. and Williams N. (2013). Resourcing Future Generations: A Proposed New IUGS Initiative. Episodes, Vol. 36, Issue 2, 82-86.

Leopold A. (1949). A Sand County Almanac. Oxford University Press.

Lewis S.L. and Maslin M.A. (2015). Defining the Anthropocene. Nature 519, 171–180, doi 10.1038/nature14258.

Liverman D.G.E, Pereira C.P.G. and Marker B. (2008). Communicating Environmental Sciences. Geological Society of London, Special Publication, No.305, 214 pages.

Lucchesi S. and Giardino M. (2012). The role of geoscientists in human progress. p. 355-359, doi: 10.4401/ag-5535. In: Peppoloni S. and Di Capua G. (2012). Geoethics and geological culture. Reflections from the Geoitalia Conference 2011. Annals of Geophysics (Special Issue), 55, 3.

Marshall A. (1993). Ethics and the Extraterrestrial Environment. Journal of Applied Philosophy, Vol. 10, No. 2, pp. 227-236.

Matteucci R., Gosso G., Peppoloni S., Piacente S., Wasowski J. (2014). The “Geoethical Promise”: A Proposal. Episodes, Vol. 37, no. 3, pp. 190-191.

Mayer T. (2015). Research integrity: The bedrock of the Geosciences. In: Wyss M. and Peppoloni S. (Eds.). Geoethics: Ethical challenges and case studies in Earth science. Elsevier, pp. 450, Waltham, Massachusetts, ISBN 978-0-12-799935-7.

McPhee J. (1989). Los Angeles against the mountains, in The Control of Nature, J. McPhee, The Noonday Press, New York.

Mogk D. and Geissman J. (2014). Developing Resources for Teaching Ethics in Geoscience. Eos, Vol. 95, No. 44.

Mogk D., Geissman J., and Bruckner M.Z. (this volume). Teaching Geoethics Across the Geoscience Curriculum: Why, When, What, How, and Where? in Gundersen, L. C. (ed) Scientific Integrity and Ethics: With Application to the Geosciences. Wiley.

Montreal Statement on Research Integrity (2013). 3rd World Conference on Research Integrity, Montreal, 5–8 May 2013. http://www.cehd.umn.edu/olpd/MontrealStatement.pdf (accessed 18 June 2015).

Munich Re (2015). *Topics Geo. Natural catastrophes 2014. Analyses, assessments, positions*. Munich. Retrieved from: http://www.munichre.com/site/mram-mobile/get/documents_E-1601714186/mram/assetpool.mr_america/PDFs/3_Publications/Topics_Geo_2014.pdf.

Næss A. (1973). The Shallow and the Deep, Long-Range Ecology Movement. A summary. Inquiry 16, p. 95-100.

Newhall C., Aramaki S., Barberi F., Blong R., Calvache M., Cheminee J.L., Punongbayan R., Siebe C., Simkin T., Sparks S. and Tjetjep W. - IAVCEI Subcommittee for Crises Protocols (1999). Professional conduct of scientists during volcanic crises -. Bulletin of Volcanology, 60, 323–334.

Oreskes N., Carlat D., Mann M.E., Thacker P.D., vom Saal F.S. (2015). Viewpoint: Why Disclosure Matters. Environ. Sci. Technol., 49 (13), pp 7527–7528. doi: 10.1021/acs.est.5b02726.

Passmore J.A. (1974). Man's Responsibility for Nature: Ecological Problems and Western Traditions. p. 213. Gerald Duckworth & Co Ltd, London, ISBN 978-0-71-560756-5.

Peppoloni S. (2012a). Ethical and cultural value of the Earth sciences. Interview with Prof. Giulio Giorello. p. 343-346, doi: 10.4401/ag-5755. In: Peppoloni S. and Di Capua G. (2012). Geoethics and geological culture. Reflections from the Geoitalia Conference 2011. Annals of Geophysics (Special Issue), 55, 3.

Peppoloni S. (2012b). Social aspects of the Earth sciences. Interview with Prof. Franco Ferrarotti. p. 347-348, doi: 10.4401/ag-5632. In: Peppoloni S. and Di Capua G. (2012). Geoethics and geological culture. Reflections from the Geoitalia Conference 2011. Annals of Geophysics (Special Issue), 55, 3.

Peppoloni S. (2015). Sharing ethical principles through cultural diversity: translations of the Montreal Statement on Research Integrity. IAPG - International Association for Promoting Geoethics, http://www.geoethics.org/translationsMS.html (accessed 10 July 2015).

Peppoloni S., Bobrowsky P., Di Capua G. (2015). Geoethics: a challenge for research integrity in geosciences. In: Steneck N.H., Mayer T., Anderson M., Kleinert S. (Eds.). Integrity in the Global Research Arena, p. 400, World Scientific, ISBN: 978-9-81-463238-6.

Peppoloni S. and Di Capua G. (2012). Geoethics and geological culture: awareness, responsibility and challenges. p. 335-341, doi: 10.4401/ag-6099. In: Peppoloni S. and Di Capua G. (2012). Geoethics and geological culture. Reflections from the Geoitalia Conference 2011. Annals of Geophysics (Special Issue), 55, 3.

Peppoloni S. and Di Capua G. (2015). The Meaning of Geoethics. pp. 3-14. In: Wyss M. and Peppoloni S. (Eds.). Geoethics: Ethical challenges and case studies in Earth science. Elsevier, pp. 450, Waltham, Massachusetts, ISBN 978-0-12-799935-7.

Pievani T. (2009). The World after Charles R. Darwin: Continuity, Unity in Diversity, Contingency, In: Rend. Fis. Acc. Lincei, Springer, 20, 355-361.

Pievani T. (2012). Geoethics and philosophy of earth sciences: the role of geophysical factors in human evolution. p. 349-353, doi: 10.4401/ag-5579. In: Peppoloni S. and Di Capua G. (2012). Geoethics and geological culture. Reflections from the Geoitalia Conference 2011. Annals of Geophysics (Special Issue), 55, 3.

Pievani T. (2015). Humans' Place in Geophysics: Understanding the Vertigo of Deep Time. pp. 57-67. In: Wyss M. and Peppoloni S. (Eds.). Geoethics: Ethical challenges and case studies in Earth science. Elsevier, pp. 450, Waltham, Massachusetts, ISBN 978-0-12-799935-7.

Pope Francis (2015). Laudato si' (Praise be to you - On Care For Our Common Home). Encyclical, http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html (accessed 25 June 2015).

Sachs J. D. (2014). Sustainable Development Goals for a New Era. Horizons, No.1, p. 106-119.

Savolainen K. (1992). Education and Human Rights: New Priorities. In: Adult Education for International Understanding, Human Rights and Peace. Report of the Workshop held at UIE, Hamburg, 18-19 April 1991, UIE Reports, n. 11, p. 43-48.

Selinus O. (Ed.) (2013). Essentials of Medical Geology: Revised Edition. Springer, XIX, 805 p., ISBN 978-94-007-4375-5.

Selle M.J. (2014). Interview to Silvia Peppoloni, in Geoethics Provides Vision for Best Practices. Hartenergy, The Official 2014 Offshore Technology Conference Newspaper, May 5, Day 1, p. 20.

Singapore Statement on Research Integrity (2010). 2nd World Conference on Research Integrity, Singapore, 21–24 July 2010, http://www.singaporestatement.org/statement.html (accessed 25 June 2015).

Slosson J.E., Williams J.W., and Cronin V.S. (1991). Current and future difficulties in the practice of engineering geology. Eng. Geol., 30, 3-12.

Stoppani A. (1873). Corso di Geologia Vol. II, G. Bernardoni e G. Brigola, Editori, Milano.

Tollefson J. (2015). Earth science wrestles with conflict-of-interest policies. Nature, 522, 403–404. doi: 10.1038/522403a.

UNESCO (2006). Global Geoparks Network, United Nations Educational, Scientific and Cultural Organization, http://unesdoc.unesco.org/images/0015/001500/150007e.pdf (accessed 25 June 2015).

United Nations. (1992). *United Nations Framework Convention on Climate Change*. FCCC/INFORMAL/84 GE.05-62220 (E) 200705. United Nations. Retrieved from: http://unfccc.int/resource/docs/convkp/conveng.pdf

WCED (1987). World Commission on Environment and Development. Our Common Future. 416 pp., Oxford University Press, ISBN 978-0-19-282080-8.

Williams J. (this volume) The National Association Of State Boards of Geology (ASBOG®) Involvement in Geoscience Professional Ethics, in in Gundersen, L. C. (ed) Scientific Integrity and Ethics: With Application to the Geosciences. Wiley.

Wyss M. and Peppoloni S. (2015). Geoethics: Ethical challenges and case studies in Earth science. Elsevier, pp. 450, Waltham, Massachusetts, ISBN 978-0-12-799935-7.

Zalasiewicz J., Waters C.N., Williams M., Barnosky A.D., Cearreta A., Crutzen P., Ellis E., Ellis M.A., Fairchild I.J., Grinevald J., Haff P.K., Hajdas I., Leinfelder R., McNeill J., Odada E.O., Poirier C., Richter D., Steffen W., Summerhayes C., Syvitski J.P.M., Vidas D., Wagreich M., Wing S.L., Wolfe A.P., Zhishengw A., Oreskes N. (2015). When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. Quaternary International (Available online 12 January 2015), http://dx.doi.org/10.1016/j.quaint.2014.11.045 (accessed 23 June 2015).

Zen E-an (1993). The Citizen-Geologist. GSA Presidential Address 1992, GSA Today, 3(1), 2-3.