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Summary

Contemporary Geoethics within Geosciences

(Silvia Peppoloni, Nic Bilham, Giuseppe Di Capua)

In recent years geoscientists have felt an increasing need to reflect on the ethical values that underlie geoscience practice and research. Understanding the Earth, discovering and using its resources, characterising natural processes and finding ways to live with their impacts, and intervening in such natural systems and processes are activities that present significant responsibilities for all citizens, and in particular for professional geoscientists. Human actions impact on complex socio-ecological systems that consist of strongly interconnected elements, and that exhibit system behaviours that can be difficult to assess. If they are to contribute to finding solutions to current global challenges that are both effective and socially acceptable, scientific advances should be complemented by consideration of their ethical and social aspects.

But what ethical criteria can guide human interaction with the Earth? How can we find a sustainable balance between conservation of the planet and economic development to find a safe operating space (Rockström et al. 2009, Steffen et al. 2015)? What is the social role of geoscientists in this context, as professionals and as citizens?

Geoethics is conceived to answer these and related questions.

The ideas that underpin the conceptual foundations of geoethics can be traced back to the eighteenth and nineteenth centuries when anthropogenic impacts on nature began to be recognised and documented (Fressoz 2012, Peppoloni and Di Capua 2012, Bonneuil and Fressoz 2013, Lucchesi 2017, Häusler 2018). Since then, major technological, industrial and social developments, the subsequent and ongoing very rapid growth of the population and urban expansion have greatly increased the effects of human interference with the Earth system. This shift confronts us with the need to consider from an ethical perspective challenges such as the sustainable use of geo-resources and energy, protection against natural and man-made hazards, the reduction of pollution, the mitigation of global environmental change and adaptation to such change.

Geoethics arises from the awareness that, in a more or less conscious manner, humankind is modifying the natural realms and territories in which it operates and lives, their physical and biological characteristics, but also the social and cultural features of their appropriation. Here the notion 'territory' encompasses the land and the sea, as human impacts extend well beyond the former. The impacts of human interventions on natural realms produce profound changes in the Earth system, which in turn influence economic development and societal prospects of people on a global scale.

The purpose of this chapter is to describe geoethics as it has evolved so far, and to outline a framework for its current conceptual structure, essential characteristics and practical applications.

The roots of geoethics are to be found in the geosciences. However, its development, albeit centred on the role and responsibility of geoscientists (Peppoloni and Di Capua 2012), should extend beyond a specific scientific and professional community. Rather than searching for and developing prescriptive norms that are to be applied to geosciences, geoethics promotes a critical attitude that is rooted in science. Geoethics seeks to transfer such attitudes for societal benefit, to foster responsible and well-informed economic, technological and social development. Geoethics has a vital role to play in shaping cultural categories and behavioural reference values founded in scientific experience and knowledge (Peppoloni and Di Capua 2016, Tuana 2017). In doing so, its social value will be demonstrated, furthering its intellectual and practical credibility.

2.1 The Origins of Geoethics

Geoethics is increasingly widely recognised as an emerging subject within the geosciences (Bobrowsky et al. 2017). Over the past few years, a growing community of geoscientists and other practitioners and professional institutions have engaged in a shared, bottom-up process to establish the main topics of geoethics as it currently stands, and to develop a robust conceptual structure by progressively defining contents, definitions, methods, tools and a shared vision. Through this participatory process, geoethics today has well-established conceptual foundations, and a developing framework for its practical application across a growing range of geoscience disciplines and sectors (Peppoloni and Di Capua 2017a).

Contemporary and past environmentalism has provided geoscientists with fresh perspectives, which have inspired (and continue to inspire) the development of geoethics. It has also contributed to furthering the sensibility of society towards the environment. Governmental regulations and international treaties reflecting conceptual formulations of environmental thinking can be seen as representing a gradual shift in economic and technological paradigms. However, this trend has not been uniform, and its continuation should not be taken for granted. It has been accompanied by value- and faith-driven discussions, controversies, social tensions and instances of political prejudice and manipulation. Complex settings in which geoscience knowledge is applied, such as mining or large-scale infrastructure development, are fraught with such tensions.

As noted in chapter 1, a distinguishing feature of geoethics is that it is actor-centric, and in particular oriented towards informing the conceptual frameworks and practical interventions of the individual scientist. Moreover, geoethics is based on geoscience knowledge. The individual (the geoscientist), who possesses a specific corpus of knowledge, is equipped to promote attitudes and ways of thinking founded on that knowledge base, including through cooperation with those who are not expert in the field, to find the most acceptable ways in which to interact with the Earth system.

Geoethics is a virtue-ethics, placing at the forefront individual responsible action based on the adoption of societal and professional reference values. Its development and application are led by scientists for the benefit of society, within a pragmatic, open and continuous revision process. It focuses on the comprehension (in the original meaning of the Latin word '*comprehendĕre*', composed of the preposition *'cum'* and the verb *'prehendere'*, that is 'to contain, to take in, to include') of physical and social realities. Geoethics is shaped and informed by a strong awareness of the technical, environmental, economic, cultural and political limits existing in different socio-ecological contexts. In other words, geoethics is context-dependent in space and time, and ethically sound choices may differ for similar ethical dilemmas. Such choices must also be guided by geoscience knowledge, which is imperfect, and is applied in a given space-time context. Geoscientists acting in a geoethical perspective should be encouraged to ask: What is right to do, here and now? How? And why? Such apparent relativism may be perceived by some as an inherent risk within geoethics, but conversely a search for prescriptive norms that ignores the importance of context is likely to be fruitless.

The essential characteristics outlined above prefigure geoethics' innovative potential.

2.1.1 From Ethics to Geoethics

The conceptual structure, content and values of geoethics have their origins in the definition and application of the more general discipline of the philosophy of ethics.

Considering a western cultural context, the Greek philosopher Aristotle (384-322 BC) characterised ethics as reflecting on the conduct of humans, and identifying legitimate criteria by which to evaluate behaviours and choices to identify 'true good', as well as the means to achieve this goal. His concept of ethics also addresses the moral obligations of human beings towards themselves and others, and principles to guide appropriate action when facing a decision. Other cultural roots may be drawn upon to trace the relation of ethics and geoethics; however, considering the predominant role of European culture in shaping and framing modern sciences, this reference may serve the purpose.

In a global society that renounces slavery, genocide and other societal atrocities, ethics must concern all humans without distinction, and have equity as a central tenet. Since the middle of the last century, there has been increased recognition of universal values as the basis for individual and social good. Codifications such as the Universal Declaration of Human Rights of the United Nations[1] set out essential ethical features for guiding human behaviour, including dignity, justice and respect for life. The principle of intergenerational equity is also fundamental to modern ethics. To make choices rationally and responsibly requires us to apply moral principles in pursuit of the greater good (Weber 1919), not just in respect of present day society but also considering the impact of one's choices on future generations (Jonas 1979). However, experience shows that the ways in which universal values such as honesty, responsibility, respect for the environment and consideration for future generations are applied vary across time and space, depending on the specific social, political and cultural context. Likewise, attitudes of those who have significant scientific, social or political roles and responsibilities vary, as well as claims regarding their constraints by ethical obligations.

Ethics has a clear purpose and means. Simplifying, it aims to clarify, for a given circumstance, how principles and values should inform appropriate action, considering the consequences of such action. Its function is to offer guiding principles to people when they need to make a choice by providing a framework of reference values, shared by the social group to which they belong, that can lead to good or to what is most useful or acceptable to the individual or society (Peppoloni and Di Capua 2018). Nevertheless, experience confirms that choices that are taken in a

[1] United Nations 1948, The Universal Declaration of Human Rights: http://www.un.org/en/universal-declaration-human-rights/

specific social and cultural setting, and respect the ethical norms of this setting, may appear unethical elsewhere. Thus the apparent relativism of geoethics, referred to above, has its roots in a fundamental feature of virtue-ethics. How to handle such ‘relativism’ is an ethical dilemma of geoethics.

Regarding the practice of a profession, ethics is expressed through the identification of duties and rights that regulate professional activity (deontology) by members of a social group, who are characterised by the possession of specific technical-scientific knowledge, methods and tools for its application (Peppoloni and Di Capua 2018).

In the field of geosciences, the term ‘geoethics’ is used to frame the ethical problems related to geoscience research and practice. As mentioned in chapter 1, *"Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system"* (Peppoloni and Di Capua 2015a p. 4-5, Bobrowsky et al. 2017 p. 5). This definition provides a basis for analysis and practice, and highlights the need to identify values on which to base the growing interaction between humans and the Earth system. Moreover, “Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities” (Di Capua et al. 2017, Peppoloni and Di Capua 2017a). This phrasing reflects the centrality of the geosciences as a significant body of technical-scientific knowledge and practice to inform human interaction with Earth. Geoscientists are asked to assume the responsibility of using their knowledge for the benefit of society. Their actions and choices are submitted to the judgment of their colleagues (scientifically and technically) and society (in terms of their wider impacts and implications). Taking responsibility therefore means being answerable for our actions, because of our competence to address the problem at hand.

2.1.2 Exploring the Meaning of the Term 'Geoethics'

Where does the word 'geoethics' originate? What are its connotations and the history of its components? Hence, what possible meanings are encapsulated in its etymological roots?

As outlined in chapter 1, the word 'geoethics' is used with different meanings, some of which have little in common. In this context, an etymological analysis can make a valuable contribution to the conceptual framework on which to base geoethics, to illuminate relevant concepts and to provide deeper understanding of its philosophical base (Peppoloni and Di Capua 2015a).

Considering its rather simple semantic construction, 'geoethics' is the union of the prefix 'geo-' and the word 'ethics'.

The prefix 'geo-' carries an ancient meaning. It refers to *'gaia'*, which means 'Earth' in Greek, but its much older Sumerian base *'ga'* refers more specifically to 'home, the dwelling place'. So the Earth is the place where humans dwell, where their ancestors dwelt, and where their children will dwell. The notion of dwelling relates directly to the more recent concept of 'niche-building' (Ellis et al. 2016).

Etymological analysis of the word 'ethics' reveals a more complex conceptual development. First, the word 'ethics' is derived from the Greek *'ἔθος' (ĕthos),* which means 'habit, custom'. This noun has the same origin as *'εἴωθα' (eiotha),* a Greek perfect form meaning 'I am accustomed to, I have the habit of, I am familiar with' (Liddell and Scott 1996). Words such as 'accustomed' and 'familiar' imply a sense of belonging to a community, be it a family or a larger social group. But what determines familiarity and therefore a habit of behaviour? This can be traced back to the Semitic root *'edum'* meaning 'experience, to be experienced in'. In other words, I experience something (an event, a circumstance), I acquire knowledge, and I familiarise myself with this event. From now on, my acquired expertise helps me to choose the behaviour or custom most suitable to a given circumstance or event. Second, the word ‘ethics’ has additional meanings. It can be traced also to the Greek *‘ῆθος’ (ēthos),* which refers more specifically to the characteristics or habits of the individual, one’s personal characteristics (Liddell and Scott 1996). Both nouns (ĕthos and ēthos) derive from the same root *‘sweth-‘* (compare to the Latin *‘suesco’*, ‘I use’, Ernout and Meillet 1994). However, the second term gives evidence of the double nature of human beings as both an individual and a member of a community. So the word ‘ethics’ can be rooted in a dual meaning: one related to the social sphere and one to the individual sphere.

The same double origin can be observed going back from Greek to the Accadian language. Starting from the Accadian base *‘esdu’*, ethics denotes ‘social foundation, social discipline’, and in a wider sense ‘assurance of continuity’. Again, we meet the social dimension, the reference of the word ‘ethics’ to the community (Semerano 2007). However, from the Accadian base *‘betu’* comes the meaning of ‘home, dwelling, shelter’. As such it can refer to something more personal and intimate. Moreover, from the Accadian base *‘ettu’*, the word ‘ethics’ assumes the meaning of ‘character, distinguishing marks of an individual, characteristic of a person’. Again, the individual sphere is referred to (Semerano 2007). Therefore, ‘ethics’ relates in origin to what individuals have in common when perceiving themselves to be part of a community.

In summary, it seems that a double meaning can be associated with the word ethics. On the one hand it contains a sense of belonging to a social dimension. On the other hand, it expresses the personal, the individual. It follows from the etymological roots that the notion ‘ethics’ concerns both the common sphere, the interactions between individuals belonging to a social organisation, and the personal sphere, what distinguishes an individual. Hence, ethics means ‘to be part of’, and at the same time ‘to belong to oneself’. These two existential conditions (social and individual) coexist in the word ethics, unexpected though this may be for many.

By analogy, these considerations can be extended to geoethics, shaping its definition on the one hand as an investigation of and reflection on the behaviour of geoscientists towards society and the Earth system (their enlarged existential dimension, as it were) and on the other hand as the analysis of the relationship between the geoscientist and her/his own actions, relative to the intimate individual dimension. In geoethics, geoscientists are called upon to shoulder not only individual responsibility, but also social and environmental responsibility. These are inextricably linked, as personal ethical attitudes are reflected in social behaviours and interactions.

2.2 Contemporary Geoethical Thinking

2.2.1 The Concept of Responsibility - Four Levels of Interaction

The concept of responsibility is a central pivot in geoethics (Hocke 2015, Peppoloni and Di Capua 2015a, 2017a). Obviously, it shares this feature with professional ethics in other disciplines (Leys 1952, Hourdequin 2015, Rozzi et al. 2015). However, the subject of geosciences introduces some peculiarities.

The word 'responsibility' derives from the Latin verb *'respòndere'*, meaning 'to respond', and so it expresses the commitment to answer to someone for our actions and their consequences – the duty to satisfactorily perform a task, which has a consequent 'penalty for failure'. For the scientific community, the 'penalty for failure' must not be conceived only in legal terms. If, for example, calculations to stabilise a slope are wrong owing to negligence and a disaster occurs, scientists may be held legally liable for the consequences. But another penalty for failure is loss of credibility (both individually and collectively as a profession), the failure of the scientific and cultural role of geoscientists to facilitate society in facing geological problems, and hence loss of rationale for being geoscientists (Peppoloni and Di Capua 2017a, 2018).

The geoscientist sits at the centre of an ethical reference system in which individual, professional, social and environmental values coexist, underpinning their responsibilities at these four levels. Geoscientists should examine their choices with reference to these values, considering their actions and interactions in the corresponding consecutively wider, more complex and entangled domains of experience (Peppoloni and Di Capua 2017a, Mogk et al. 2017).

Firstly, the geoscientist's responsibility is towards her/himself, in conducting their work to the best of their own ability. This means pursuing excellence in science, applying appropriate methods and technologies in scientific research and application, and following (and contributing to the development and promulgation of) best scientific and professional practice. Examples include: maintaining high standards of intellectual honesty; verifying sources of information; reporting findings and interpretations fully and objectively; not altering or ignoring evidence to strengthen one's argument; making clear any limitations or gaps in evidence and information; being honest about the limits of one's own knowledge and competence, and acting within these limits; avoiding conflicts of interest wherever possible, and declaring any potential conflicts of interest; and engaging in ongoing professional training and the continuous improvement of geoscience knowledge throughout one's career (Mayer 2015, Peppoloni et al. 2015, Abbott 2017a, Mogk 2017).

Secondly, the geoscientist should assess her/his actions with respect to their working environment, colleagues and wider profession. In common with other scientists, it is the individual's responsibility to cooperate and treat colleagues honestly and fairly; to respect others' ideas, welcome fair debate and embrace a diversity of perspectives, expertise and methods; to foster mutual understanding, share information and data, and support the intellectual and professional development of others; to respect and acknowledge the intellectual property of others; and not to compete unfairly – for instance, recognising if others are better qualified to carry out the work at hand.

The geoscientist produces knowledge and designs solutions for the benefit of society and its component parts. It is the individual's responsibility to serve society as effectively as possible, in order to support its development and assure its safety. To achieve those goals, as in other sciences, it is essential to take care of the 'data life cycle' (Gundersen 2017), including making data and the results of one's studies public (Van Gessel et al. 2017). Research results and the implications of their application should be shared with relevant public and non-expert audiences in ways that address their knowledge, interests, needs and concerns, are easily accessible and user-friendly, and are contextualised with explanatory information. Geoscientists should take similar care when communicating their knowledge to policy-makers and public bodies at all levels, in which they should take an active part, and should seek to develop constructive and responsible interactions between academia and industry. They have a key role to play in the training and skills development of technicians and professionals, and in participating in public engagement, awareness raising and educational activities.

Finally, geoscientists' role in helping to manage the natural realm, understood in a more general sense than just the terrestrial, brings with it a responsibility towards the environment. They have knowledge, expertise, professional and cultural sensibility that are essential to protect natural environments, to manage the development of natural resources and places so as to minimise negative impacts on ecosystems, to enhance the scientific, educational, cultural and aesthetic value of bio- and geodiversity, and to entrust these to future generations.

Given the importance of the concept of responsibility, it is vital periodically to review the scope and nature of geoscientists' action and involvement in each specific context, and therefore to understand their role in wider decision-making and implementation processes (Bobrowsky et al. 2017, Dolce and Di Bucci 2015). Notwithstanding the specificity of particular geoscience disciplines, further research is needed to clarify the distinctive features of how geoscience and decision-making (including policy-making) interact, vis-à-vis science-policy-society interaction more generally (Douglas 2009, Gluckman 2014, Kowarsch 2016, Kowarsch et al., 2016), as recognised in chapter 1.

However, it is also important to realise that responsibility does not rest solely with the geoscientist since s/he usually helps other actors to operate using geoscience knowledge; likewise, responsibility is not held only by scientists in general. The need to assign responsibility fairly to individual actors is a feature of structured, engineering-like operational processes that characterise many geoscience professions. Where different actors share responsibility, a shared value system is helpful for fostering sound cooperation. A clear distinction of roles and a common foundation that allows for shared understanding are both fundamental when multiple professional actors cooperate to handle complex problems or when different stakeholders are involved. Geosciences are rich in such situations, for example in risk management, that require well-defined and shared operational protocols, to avoid overlapping tasks and assure clarity in the decision-making process.

2.2.2 Reference Values on Which to Base Geoethical Perspectives and Actions

To better understand the responsibilities of geoscientists and to inform their actions, it is essential to identify reference values capable of guiding choices and behaviours across a wide range of settings, on the basis of which to discriminate better, more beneficial or more acceptable decisions and choices from worse, less beneficial or less acceptable ones. Those values must be rooted in awareness of the social and environmental implications of geoscientists' activities and their related responsibilities towards society, future generations and the Earth.

Three sets of values are proposed, grouped according to their functional aim, although these often intersect (Peppoloni and Di Capua 2016).

2.2.2.1 Ethical Values

The Singapore and Montreal Statements[2] have established internationally a set of reference principles on which to base research integrity (Mayer 2015, Steneck et al. 2017). Similarly, professional or ethical codes[3] developed over many years by professional geoscience institutions have defined ethical norms for professional activities (Allington and Fernandez-Fuentes 2014, Abbott 2017a, Abbott 2017b, Boland and Mogk 2017, McPhaden 2017). Typically these include many (though not all) of the values set out above in relation to the individual, professional, social and environmental spheres, and are associated with a 'penalty for failure' for the individual, policed at the professional level through the institutions' disciplinary procedures. They can be considered 'deontological codes', in that they codify rules for ethical professional behaviours, although the motivations for their establishment and maintenance have their roots in virtue-ethics (in that they seek to encapsulate what is morally right for the professional geoscientist to do) and utilitarianism (in that they deliver public benefit, and promote and defend the legitimacy and credibility of the individual and the profession).

The common matrix of these reference documents can be traced back to fundamental values that apply across scientific/scholarly disciplines, such as honesty, accountability, professionalism, and stewardship. These values can be integrated with awareness, accuracy, cooperation, inclusiveness, and fairness. They assure professional courtesy in working with others, good stewardship of activities, adherence to regulations and to scientific methods, repeatability of studies by colleagues and sharing of the results, respect of intellectual property and of rules on authorship and the peer review process, and due scrutiny of conflicts of interest (Mogk 2017).

In the era of globalisation, where issues of environment, climate, infrastructure, resources and energy have no borders and require international efforts for their management, it is important to

[2] "Singapore Statement on Research Integrity" (2010) and "Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations" (2013): https://wcrif.org/guidance
[3] such as those listed at http://www.geoethics.org/codes

promote a shared ethical set of values among geoscientists around the world. Beyond concern for the commonalities and tensions of a globalised world, many geoscientists exercise their professions in different parts of the world, from exploration for minerals in Africa to seafloor studies in the Pacific. Social, political, cultural, technological and economic differences among nations can cause tensions when facing issues such as research integrity and the ethical conduct of professional activity. It is important to assure some common ethical values and standards that extend beyond national boundaries. Such considerations have driven international efforts to promote common professional standards in geoscience, including mutual recognition agreements between professional bodies, the work of the European Federation of Geologists[4] and the establishment of a Task Group on Global Geoscience Professionalism[5] by the International Union of Geological Sciences, among others.

Ethical values in respect of international cooperation aim to involve geoscientists from all over the world in the discussion of global issues, and to debate and compare ideas, even if these are very different, in the search for common solutions. Moreover, a set of shared ethical values is essential if multidisciplinary work is to reach its full potential, allowing the effective integration of different specialist disciplines and professional skills in facing problems.

Often cross-boundary research and professional collaborations (whether across disciplinary or national boundaries) present special challenges for the responsible conduct of scientific and technical activities (Mayer 2015), because they may involve substantial differences in regulatory and legal systems, organisational and funding structures, research cultures, and approaches to training. It is critically important, therefore, that geoscientists are aware of and able to address such differences. Principles of utmost importance are trust, transparency, communication, and compliance with laws, policies, regulations and publishing rules.

[4] https://eurogeologists.eu
[5] https://tg-ggp.org

2.2.2.2 Cultural Values

Geoethical thinking highlights and enhances the social and cultural dimensions of the geosciences. Identifying and promoting the cultural values associated with geoscience research and practice can help guide society in its choice of responsible behaviours towards the Earth, in both its biotic (e.g. biodiversity) and abiotic (e.g. geodiversity) components (Peppoloni and Di Capua 2012) which are inextricably linked.

Concepts such as geoheritage, geoconservation and geodiversity bring together not only scientific but also cultural elements, tangible or otherwise. These concepts have been informally addressed for many years by the geosciences, but a need for greater formality and definition of terms has arisen only relatively recently, particularly in seeking dialogue across disciplines and with policy-makers. Notwithstanding a plethora of alternative definitions, geodiversity is defined as *"the variety of natural elements, such as minerals, rocks, fossils, landforms and their landscapes, soils, and active geological/geomorphological processes"* (ProGEO 2017, p. 1). Geoheritage comprises those "elements of the Earth's geodiversity that are considered to have significant scientific, educational, cultural, aesthetic, ecological or ecosystem service values" (Woo 2017). Geoconservation comprises actions taken to preserve geodiversity and geoheritage in order to ensure that the 'face' of the planet (rocks, landscapes, waters) is adequately protected from human interventions for future generations (Bobrowsky et al. 2017, ProGEO 2017).

These concepts, their enhancement and their promulgation represent an important resource for strengthening the relationship and the sense of belonging of the population to the land it inhabits, contributing to richer understandings of the identity of human communities, and focusing attention and care towards the socio-natural environment. Geoheritage, geodiversity, and geoconservation are practical expressions of taking a geoethical view of the planet: recognising their importance as a means to restoring an inner connection between humans and the Earth system is a fundamental starting point to develop best practices in managing environments. At the same time, geoethics highlights their intrinsic social and economic value, since geoheritage and geodiversity form part of non-renewable societal and natural capital.

Initiatives such as UNESCO Global Geoparks[6] and sectors such as geotourism[7] (Allan 2015) are the material expression of those values, and a means of celebrating and interpreting the geological landscape, resulting in a broader understanding of geosciences through appreciation and learning (Gordon 2018). In these terms, geosciences are capable of influencing people’s ways of thinking about the planet. If properly managed, geoparks can provide opportunities for a country’s sustainable development, in which geosciences and social sciences interact on common ground. In particular, the Geopark movement is a global phenomenon that offers many benefits, such as: effective multidisciplinary work and cross-border international collaboration; an increase in public awareness and education; improved quality of life for local populations through economic stimulus; and a general move towards greater awareness of the importance and diversity of nature.

2.2.2.3 Social Values

Facing great challenges, such as mitigation of climate change and adaptation to it, the search for new sources of energy, the need for a sustainable approach to the environment and defence against geo-hazards can and must be pursued through diverse approaches and perspectives. Geoethics seeks to provide a common matrix to address those issues in a wider and indeed global perspective. As a consequence, an aim of geoethics research is to search for social values capable of bringing together diverse cultures and sensibilities.

[6] http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks
[7] International Congress Arouca 2011, Arouca Declaration on Geoturism: http://www.europeangeoparks.org/?p=223

General societal concepts that are widely applicable across such fundamental challenges, such as sustainability, prevention, adaptation and education, can be regarded as a set of shared social values, helping to frame a new common vision for our societies in the coming decades. These concepts are introduced below in general terms, and their application to geoscience is addressed later in this chapter.

First, the concept of sustainability presents us with a double challenge, but promises a corresponding double social value. It raises the need, for example, to minimise and optimise the production and use of energy and minerals, and to facilitate transition to the use of renewable energies; and informs development of strategies and technologies for doing so, maximising the positive and minimising the negative social and environmental impacts of such resource use. However, it also highlights the need to build new models of economic development, recognising that it is a fundamental human right not to live in poverty and that a global society that ignores this right cannot be truly sustainable. The concept of 'sustainable development' (explored in greater detail below) captures a tension between the need to facilitate the economic and social development of the world's poor and the need to reduce and, where possible, reverse damage to the Earth system – but it also raises the possibility of reconciling these challenges. Geoethics should help to define the boundaries of how to live sustainably on the planet.

Second, prevention refers to a set of activities and tools, either to prevent processes or events from happening, or to prevent harm resulting from these. The development of a culture centred on prevention is a way to improve the resilience of human communities, namely their ability to anticipate, avoid and/or respond to an event. This includes the capacity to restore the material, cultural and spiritual conditions that existed before an event, and to prepare for and respond to future events in a more effective way. Considered in risk management terms, prevention strategies can be seen as aiming to break the pathway either between possible causes and a risk event (proactive controls), or between the event and its possible consequences (reactive controls).

Developing resilient prevention strategies requires access to accurate scientific information, communication and education, as well as effective governance. It also depends on improving communities' awareness of natural risks, and their capacity to assess and establish reasonable risk thresholds which are considered acceptable, and hence the adoption of strategies that reduce the likelihood that a potentially damaging natural event or process occurs, or that such an event is transformed into a disaster.

Third, human adaptation refers to the ability of a social group to modify its characteristics and the ways it interacts with its environment in response to change. The necessity to consider adaptation arises from the observation that natural systems are often altered in an irreversible manner, given their interconnectedness and complexity, often characterised by non-linear system dynamics that hinder restoration of earlier conditions. Beyond the need to handle environmental change and to ensure the survival of society, adaptation is also a way for communities to strengthen their internal social ties in pursuit of a common benefit.

Fourth, '(geo-)education' is an important social value in geoethics. Developing and disseminating a culture of Earth-science literacy across society is essential to change the way in which people perceive their relationship with the Earth system, equipping and empowering them to participate in debate and action to address global challenges, as well as providing the basis for the education and training of future generations of geoscientists whose skills will be essential to meeting these challenges. Geosciences must have a fundamental role in building a knowledgeable society, raising awareness about how the Earth system operates and evolves and how we interact with it, and equipping us with the intellectual and practical tools to do so responsibly.

A primary task of geoethics is to make communities beyond the geoscience profession aware of the immense value of those concepts, and the need to pursue them to assure human safety and progress.

2.2.3 Intellectual Freedom: A Fundamental Pre-Requisite for Practicing Geoethics

Geoethics entails a conscious and rational way of acting. An ethical decision can only arise from responsible choice. Intellectual freedom is a fundamental pre-requisite for acting ethically. To be credible, geoscientists must adhere to scientific methodologies. They must use their geoscience knowledge impartially, without being influenced in their methods or conclusions by external pressures or conflicting interests. In particular, their professional endeavours should not be driven by opportunism, political pressures or economic interests (Gaur 2015, Gawthrop 2015, Wyss 2015).

Likewise, harassment, bullying, discrimination and exploitation of power dynamics threaten the integrity of geoscientists' working environments, and inhibit their freedom of choice. A respectful working environment is fundamental to maintaining professional standards and assuring ethical conduct when practicing geosciences. Harassment (sexual, psychological or physical) and discrimination (whether on grounds of gender, race, disability, sexual orientation, religion or any other characteristic) offend the dignity of the person, and seriously undermine not only integrity and credibility of the geoscience community (Williams et al. 2017), but also in turn the quality of scientific work. These kinds of behaviour prevent individuals, driven by fear of punishment or retaliation, from taking decisions in an ethical manner (Peppoloni and Di Capua 2017a). The need for the geoscience community to address harassment and discrimination, to ensure that working and educational environments are respectful and inclusive and that unacceptable behaviours are identified and effectively policed, is increasingly being recognised in the policies and ethical codes of professional geoscience organisations – an instance of such codes evolving to meet changing needs.

Furthermore, principles such as adherence to truth, freedom from conflicting personal interests, openness to cooperation and open discussion with other colleagues should be the basis on which to found scientific activity, in whatever field (applied, academic or educational). A geoscientist who is working in an environment that pursues these values is well-placed to scrutinise the integrity and honesty of their own and others' scientific research and practice, and to ensure that the access to research results is open. She/he should be aware that scientific validity cannot be negotiated, obscured or influenced by conventions or agreements between power groups, companies or states. Recognising and pursuing these principles should be the responsibility and mission of every geoscientist.

Nonetheless, it is evident that where strong partisan interests are at play, whether in commercial, academic or government settings, this freedom is not easily won or guaranteed. For example, geoscientists working in mining or oil and gas companies may find themselves under pressure to support choices that are not in line with their professional ethics, notwithstanding the fact that they are operating in publicly regulated legal frameworks. In such egregious instances of pressure being unfairly and explicitly exerted, the ethical course of action should not be hard to discern, however difficult it is to achieve – the individual should always act ethically, and should always be allowed to do so. But aside from such clear-cut cases, ethical challenges may arise when legitimate commercial, political or economic factors come into conflict with individual or collective ethical principles. In these cases, identifying the best course of action may be less simple and clear-cut. What considerations should take precedence? Is it possible to find an acceptable balance in this dialectic relationship?

This problem, though far from being easy to resolve (Gaur 2015), may be addressed by means of the adoption of common values and rules to accommodate the diversity of relevant factors and perspectives. Aligning companies' needs (and society's demand for resources) more closely with inalienable requirements such as respect for personal ethics, environments and communities is an area of active development, which is yielding concrete results. In the field of mining, a number of initiatives are underway, at various stages of development, to establish principles and implement mechanisms to address these challenges (Nurmi 2017), such as those developed by the International

Council on Mining and Metals[8]. Whatever approaches are adopted, however, rigorous application of ethical criteria implies the risk that individuals face insoluble dilemmas. Such challenges, though far from being unique to geosciences, should be studied from a geoethical perspective to assist the geoscientists facing them in a professional capacity. It is also incumbent on geoscientists in leadership positions to promote supportive and inclusive professional environments in which such sensitive and complex matters can be addressed honestly and openly.

2.3 Ethical Issues and Ethical Dilemmas

A geoethical issue might be assumed to be a choice between at least two alternatives, one of which is the best option, taking into account the reference system of scientific, economic, social and cultural values in which a geoscientist is acting, and assuming complete and accurate knowledge of the problem faced and adequate competence for its resolution (Peppoloni and Di Capua 2018). If one option is patently better than another, then the decision to be taken may be relatively simple. But often geoscientists are faced with true ethical dilemmas (Bilham 2015): in these cases, an 'ideal' choice is not possible, but rather different options exist, all with different benefits and negative impacts on society or the environment (Marone and Peppoloni 2017). Under such circumstances, how can a choice be taken from an ethical point of view? On what should geoscientists base their choices?

A real ethical dilemma has no perfect solution, but rather one which is deemed most acceptable in a specific economic, social, cultural and environmental context. Identifying the most acceptable solution requires consideration of both positive and negative consequences of the options available, and choosing the one that maximises the benefits and minimises the disbenefits. It follows that even the 'best' solution may have adverse consequences that must be accepted. Making

[8] http://www.icmm.com

technical-scientific choices under uncertainty (Albarello 2015, Tinti et al. 2015) inevitably implies accepting compromises, a feature that is common to applied sciences (Christensen et al. 2007, Hansson 2015, Murphy et al. 2015).

Deciding on the feasibility and desirability of a course of action (for example regarding a proposed infrastructure project, an energy initiative or a hazard prevention scheme) may depend not only on scientific and technical considerations, but also on economic, political, social and cultural factors. Making an ethical choice depends on assessing these factors in the context not only of the geoscientist's own perspective and values, but also those of other stakeholders and communities who may be affected (positively or negatively) – values which may conflict (Peppoloni and Di Capua 2017a). For example, a dam may have significant adverse impacts on natural habitats, but at the same time it can ensure protection from floods and supply water to thousands of people. Similarly, a mine might be seen as a threat to its environment and the health of local communities, but may also bring benefits in the form of jobs, facilities and infrastructure improvement, as well as providing the mineral resources needed for low-carbon technologies, for instance. It is therefore vital to work with local communities and stakeholders to determine where there is reasonable alignment of economic, social, cultural and ethical values, to work to reconcile these, and to seek opportunities for collaborative action to maximise social and environmental benefit (Owen and Kemp 2013, Hostettler 2015, Arvanitidis et al. 2017). Considering more generic reference values such as sustainability and community resilience is also important, and may help to frame efforts to resolve conflicting interests.

In most applications, it is not the geoscientist who takes the final decision about a specific matter. In this case, geoscientists have a professional responsibility to provide decision-makers with information and advice (based on professional judgment rather than personal views) on all aspects of the problem that they consider relevant to a decision for the given social and environmental context, and in light of more generic reference values.

However, policy-makers and other decision-makers often expect a geoscientist (or other professional expert) to recommend a solution, or at least to advise on the desirability of options, notwithstanding their dependence on matters outside the geoscientist's professional competence (Bobrowsky et al. 2017). When geoscientists are facing a geoethical dilemma, they should accept and make clear to others that they cannot offer a unique solution, but instead define and characterise options, scenarios and potential outcomes. Geoscientists' duty (with other relevant professionals) is to explain the choices and the consequences of each of them. In doing so, they should avoid making the mistake of considering geoscience knowledge as a 'universal law', thinking they might solve an ethical dilemma based on geoscientific considerations alone, or by using categories like 'right' or 'wrong' (Marone and Peppoloni 2017). Geoscientists can help to ensure that geoethical decisions are reached by characterising problems and options adequately from a scientific and technical point of view, and by clearly indicating the positive and negative impacts of the options available. In many cases, it may be appropriate to carry out a cost/benefit analysis (Potthast 2015, Stefanovic 2015), framed in societal and environmental as well as economic terms, looking at positive and negative impacts from multiple perspectives, in the short and long term, and on small and large physical scales. Such analyses should also take into account uncertainties (quantified where possible) internal and external to the system under consideration, and recognise that such cost/benefit analysis alone may not provide an optimal (or even acceptable) solution (Peppoloni and Di Capua 2018). There is an extensive literature on science-policy interactions exploring these and related themes, albeit not focused on geoscience, which has been influential on practice in this area in recent years (see, for example, Douglas 2009, Gluckman 2014).

2.4 Geoethics Applied to Geosciences

Geoethics covers the entire range of geoscience applications, from basic research to commercial undertakings. In recent years, its application in different realms has been analysed, including through paradigmatic case studies (Peppoloni and Di Capua 2015b, Wyss and Peppoloni 2015, Gundersen 2017, Peppoloni et al. 2017).

The main issues and topics geoethics addresses include: sustainable use of natural resources (included water, energy, mineral and biological resources); the reduction and management of natural and anthropogenic risks; the management of land, coastal areas, seas and open oceans; pollution and its impacts on health; global environmental change, including climate change; protection of natural environments; research integrity and the development of codes of scientific and professional conduct; literacy and education in geosciences; geodiversity, geoheritage, geoparks and geotourism; forensic geology; and medical geology.

Returning to the question ‘On what should geoscientists base their choices?’, some of the key principles which guide the practical application of geoethics to these issues and topics are: to encourage critical analysis and the responsible use of natural resources; to promote accurate and useful information on hazards and environmental risks; to foster the development of environmentally friendly technologies; to highlight the social role of the geosciences; and to promote geological heritage as a scientific, cultural and educational resource. These principles are all aimed at guiding society in its choice of appropriate behaviours with respect to the practical problems humanity is facing in relation to the Earth system, trying to find solutions compatible with economic and social development and the conservation of nature and the land.

Consequently, even though geoethics originates in the field of geosciences and refers in the first instance to the scientific and professional activity of the geoscientist, it goes beyond this sphere of influence, turning towards other elements of society and contributing to economic, political and cultural debate. These matters are explored further in chapter 3.

2.4.1 The Specific Knowledge and Skills of Geoscientists

Geoscientists are social actors as well as scientists and professionals. Geoscientists, engineers and others with expertise relating to the Earth possess scientific knowledge, skills and training which are essential for investigating, managing and intervening in various elements of the Earth system and that can contribute to fostering better science-society relations (Gill 2016, Tubman and Escobar-Wolf 2016). This entails ethical obligations. Geoscientists' work to understand how the Earth system functions, the nature and distribution of resources, environmental dynamics and the interaction of human and natural processes carries with it the responsibility to best serve the public good.

A geoethical approach can help in turn to develop geoscientists' own knowledge, skills and capabilities. As discussed above, following ethical criteria such as honesty, openness and adherence to scientific methodology (while recognising its limits) is vital for the success of geoscientists' research and practice, facilitating the connection of scientific validity, freedom and responsibility in their work. Furthermore, it allows geoscientists to reflect on their activities, improve their professional and personal practice, and learn more about themselves, whether in research, teaching or applied professions. Scientific research and its practical application must be carried out with intellectual honesty out of respect for oneself, in order also to be of real service to others. In this spirit, geoethics can serve geoscientists in confirming (and in many cases rediscovering) fundamental elements of their identity, on which to build their own professional motivation and a personal ethics of responsibility, and informing their own social function. In this perspective, geoethics can provide the 'philosophical bonds' of a cohesive geoscience community.

2.4.2 Why Should We Act Ethically? Geoethics as an Advantage

So how does a community promote the idea that its members should behave ethically? As suggested in Bobrowsky et al. (2017), *"three steps seem to be necessary. First, ethical behaviour should be affirmed by the community as the expected norm. Second, ethical behaviour should be taught as well as modelled in both formal and informal educational settings. Third, unethical behaviour should be identified as unacceptable, and there should be undesirable consequences for such behaviour"*.

In order to encourage the spread of (geo)ethical behaviours and practices in the geoscience community, the advantages of acting ethically, following ethical values and best practice, should be highlighted and fostered, and given a central place in geoscience education. Conducting geoscience activities in a responsible way means finding wiser and cheaper technical solutions, winning the trust of clients and communities, and earning professional and scientific credibility and legitimacy. At the same time, it is important to create cultural, social and legal conditions such that there is no advantage for geoscientists, within companies or acting as individual professionals, to act unethically, because of the negative repercussions on their reputation or in terms of penalties. This is not to minimise the intrinsic value of ethical action, but its beneficial aspects should also be emphasised. To follow such an approach is to recognise the value of utilitarian and deontological perspectives on geoethics, notwithstanding its primary characterisation as a virtue-ethics.

2.4.3 Towards Society: Addressing Global Issues

Society faces a nexus of global challenges, and these must be the overriding priority for science, as well as for political and public debate and decision-making, in the coming decades. Securing sufficient food, energy, raw materials and water for all, ensuring human health, managing competing demands for land, maintaining soil quality and protecting natural environments and ecosystems, locally and globally, are closely interlinked challenges. These are exacerbated by a large and growing human population, major movements of people (including urbanisation), past and present over-exploitation of resources, rampant consumerism in post-industrial societies and massive inequalities in wealth, health and access to resources. The 17 Sustainable Development Goals of the United Nations[9], for the period 2015-2030, summarise and emphasise the importance of solving these issues as a joint challenge.

Climate change, as one feature of wider global environmental change, constitutes an existential threat to society and natural systems, requiring (among other work) the study of past climates, the continuous monitoring of environmental parameters and the modelling of possible scenarios, to inform shared global political and social action. The 2015 COP 21 Paris Agreement, to which 195 nations were signatories, establishes shared objectives for limiting carbon emissions, and provides a framework for the actions and investment required for a low carbon, resilient and sustainable future[10].

Disaster risk reduction is another fundamental objective, achievement of which will depend on continued multidisciplinary research, development of early warning systems and monitoring networks, and information and capability-building campaigns aimed at citizens. The Sendai Framework for Disaster Risk Reduction 2015-2030[11] is the first major agreement of the post-2015 development agenda, with four priorities for action. It is an agreement which recognises that the state has the primary role in preventing and reducing disaster risk, but that responsibility should be shared with other stakeholders including local government and the private sector.

Geoscience has a vital role to play in addressing all of these challenges (Gill and Bullough 2017). At their heart are international efforts to build more effective global governance frameworks (Nickless 2017), and to increase the resilience and preparedness of communities, by developing and

[9] https://www.un.org/sustainabledevelopment
[10] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[11] https://www.unisdr.org/we/coordinate/sendai-framework

promoting appropriate tools, awareness-raising and educational campaigns, and facilitating genuine multilateral communication and engagement. In this context, geoscientists' competence beyond the merely technical becomes indispensable, and the ethical value of their expertise assumes global implications. We return here to the four generic social values in geoethics that were outlined earlier in the chapter – sustainability, prevention, adaptation and education – and provide illustrations of their relevance to these challenges.

2.4.3.1 Sustainable Development

Geoscientists recognise that natural resources in the Earth system are finite. Sustainability as a value (in some form) is almost universally acknowledged by human cultures, although it is not obvious how to define sustainability in different contexts.

In 1987, the Brundtland Commission of the United Nations introduced the concept of ‘sustainable development’, as follows:

“Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities” (WCED 1987).

This definition links the concept of sustainability to the need for natural resource use and the right to economic and social development, especially for the world’s poor. In the case of geo-resources, among others, sustainability is a concept deeply linked to human needs (Grunwald 2015). In a wider sense, this definition implies ideals of social and environmental justice, intergenerational justice, the fair distribution of resources and opportunities (equity), and the concept of democracy, since it calls, even if not explicitly, for a shared governance at local and global level, triggering the concept of ‘sustainability ethics’ (Becker 2012, Ott 2014, Ness and Zondervan 2017).

Sustainability is a value that, in practice, is still often disregarded or at least undervalued in current human development models and decision-making. Including it systematically and simultaneously in its environmental, social and economic dimensions needs a pervasive and ongoing cultural shift. The tangible results of human action affecting the Earth system are increasingly evident.

Treaties, agreements and conventions are beginning to establish internationally agreed principles and rules on which to base our behaviour regarding resources, pollution, climate and sustainability, and to find an acceptable balance between environmental protection and economic and social development. At the root of geoethics is the idea that there is a unique community of life on Earth, of which humankind is an inseparable part. The Earth is the human home, on which our life and future depend. Therefore, as humans, we must respect the Earth and its natural systems and pay attention to how we interact with it, in the awareness that being part of this community of life involves considering the prudent use of its resources and the conservation of its ecosystems. But it is equally evident that it is necessary that development and sustainability must coexist, and that we should explore how they can be reconciled, for example through concepts such as ‘restorative sustainability’ – that is, ensuring that interventions such as resource extraction do net good rather than net harm (Wessel 2016).

The contribution of geoscientists is indispensable on different levels (Stewart and Gill 2017), not least in revealing some hidden contradictions and ambiguities. Often, choices that are widely considered more sustainable or more environmentally friendly than others may not be, at least in an absolute sense. For example, many technologies and strategies for reducing fossil fuel use will require very significant quantities of mineral resources – these include many metals which have not previously been widely used, as well as bulk metals such as copper (Nickless 2017). The extraction and processing of these minerals, and the complex interlinked global supply chains that stem from them, if not carefully managed, pose significant environmental risks, as well as potential social harm in the form of ‘conflict minerals’, human rights abuses in the artisanal mining sector (including in relation to child labour), and many other less visible impacts on communities. Such contradictions and ambiguities must be identified and addressed with relevant stakeholders and communities. The geoscientist also has the ethical responsibility to use geoscience knowledge to help frame these problems, inform decision-making, and facilitate effective and sensitive implementation of these decisions.

2.4.3.2 Prevention: A Common Resource for Defence Against Georisks

As clearly indicated in the Sendai Framework for Disaster Risk Reduction, strategies aimed at protecting communities against georisks requires the engagement and partnership of all parts of society. In line with concepts developed in this document, geoethics aims to improve the relationships between the geoscience community and other actors in society (such as decision-makers, local authorities, government agencies, the media and citizens) during all the phases that characterise the disaster cycle (from prevention to emergency and recovery phase). Each of these actors, with a specific role, commitment and responsibility, is part of a ‘defence system’ against an impending risk (Di Capua and Peppoloni 2014, Dolce and Di Bucci 2015, Peppoloni and Di Capua 2017b).

Moreover, geoethics contributes to strengthen the science-society interface, promoting some important actions that involve the social responsibility of the geoscientist (Di Capua and Peppoloni 2014, Limaye 2015, Peppoloni and Di Capua 2017b), such as the accurate and appropriate dissemination and communication of the results of scientific studies on geohazards (Liverman 2009, Marone et al. 2015a and 2015b, Foresta Martin and Peppoloni 2017), the development and promotion of geo-educational tools to improve knowledge about risks and preparedness of the population (Frankenberg et al. 2013), as well as the engagement of hazard-prone populations in participating in bottom-up risk communication approaches (Ickert and Stewart 2016, Stewart et al. 2017), to increase community resilience.

However, we must not neglect some current limitations to the effectiveness of risk communication, well highlighted by Wachinger et al. (2013): what seems obvious, namely that a high level of risk perception will lead to personal preparedness and, as the next step, to risk mitigation behaviour, is not necessarily true. This should be considered for risk governance and communication, as well as for the willingness of individuals to invest in risk preparedness or risk mitigation actions.

Nowadays geoscientists are able to predict or forecast, with varying degrees of uncertainty, the onset and development over time of some natural phenomena. Concepts such as probability, error and uncertainty are expressed mathematically in order to assess hazards and develop appropriate policies in risk management, even in the absence of complete scientific certainty about causes and evolution of phenomena (Albarello 2015, Potthast 2015, Tinti et al. 2015, Beven et al. 2018a, Beven et al. 2018b). Moreover, the progress of science is generating new tools to defend society against natural risks: new methods for the continuous monitoring of phenomena, use of early warning methods, efficient building techniques to ensure safety, adequate prevention programs, careful land management, and appropriate education to citizens. All these activities can be considered ‘prevention’, as framed earlier. Prevention in this broad sense can make multiple contributions to achieving safer ways to live with georisks.

Risks are not entirely avoidable, but they can be reduced below a threshold that society considers acceptable. The earthquake engineer Giuseppe Grandori (1921-2011) defined the acceptable limit of risk to society through this short statement: "*defending oneself from earthquakes means reducing the consequences of earthquakes (casualties and property damage) below a limit* *that society considers acceptable, considering the costs that a further reduction of the limit would imply*". This statement reminds us of the need for prudence and common sense, concepts on which the general vision of geoethics is based. Applying the values of prudence and common sense to real-world cases helps us to limit mistakes and overcome doubts about the choices to be made to minimise negative consequences.

In every circumstance where a risk is present, it is necessary to assess the costs but also the benefits of a risk mitigation strategy. A strategy which today may seem wasteful could be effective when evaluated in a broader perspective, looking at all likely outcomes. As a consequence, prevention must be considered not only in terms of cost savings, but primarily as a social and cultural attitude that bears fruit especially when taking systemic and long-term perspectives, so as to avoid irresponsibly transferring the social and economic costs of a disaster onto the shoulders of future generations or distant communities (Di Capua and Peppoloni 2014, Hocke 2015, Peppoloni and Di Capua 2017b).

In these terms, prevention is a value, despite human societies not perceiving it as such. It should be the duty of geoscientists, as experts in risk, to transfer this value to society, as a rational and responsible response to the right to safety of each citizen.

2.4.3.3 Adaptation to Climate Change

With reference to biological systems, ‘adaptation’ is the process by which living beings adapt morphologically and physiologically to environmental conditions, determining not only the fate of individuals and populations, but the success or failure of a species in evolutionary terms.

Humanity has always had to adapt to environmental changes, initially in biological terms but also through cultural adaptation (Foley et al. 2013). Today, adaptation signifies the need for technological, energetic, economic and cultural change processes, in response to changed environmental conditions (Klein 2011). In this perspective, in times of climate change, adaptation becomes a necessary social and cultural programme, however successful (equally necessary) prevention efforts may be. Making ethical decisions to inform adaptive programmes will require a new way of understanding the interdependencies between human and Earth systems.

Climate change adaptation seeks to reduce the vulnerability of social and biological systems and to mitigate and offset effects of global warming, albeit with *"barriers, limits and costs which are not fully understood"* (from Climate Change 2007: Synthesis Report[12]). Adapting and mitigating can mean reducing vulnerability and increasing community resilience (Adger et al. 2005), reducing system or community sensitivity, or building capacity to adapt. It may also present opportunities for development (Betsill 2001, Conway and Schipper 2011), for example as a result of investing in new research and technologies, reduced vulnerability to other hazards, or development of novel and sustainable economic pathways. Increased global awareness of our interdependence and therefore the need for common responses is also a significant consequence in itself, which could push citizens and governments to assume a more active attitude.

The challenge for human communities is to govern this adaptation responsibly, not only in technological but also cultural terms. From this point of view the COP 21 Paris Agreement, despite having debateable direct impact, demonstrates the growing political will of the international community in this direction: a common conscience is developing. An earlier exemplar is the successful adoption of policies to counter the destruction of the ozone layer, which are now recognised as having done much to reverse ozone depletion in the 2000s, thanks to the 1987 Montreal Protocol[13].

[12] https://www.ipcc.ch/publications_and_data/ar4/syr/en/spms4.html
[13] http://ozone.unep.org/montreal-protocol-substances-deplete-ozone-layer/32506

In light of these new societal conditions, the geoscience community has a momentous ethical responsibility (Kowarsch et al. 2016). Geoscientists exploring the implications of geoethics should not shy away from contributing innovative and context-specific responses to inform responsible decision-making and actions.

2.4.3.4 Geo-education: A Duty for Geoscientists, a Benefit for Society

The advancement of geoscience knowledge has been fundamental for mankind, facilitating the development of modern thought and culture, and ensuring progress and well-being for societies. In the past, geoscience has posed philosophical problems, and even today it continues to be a fundamental part of human culture (Peppoloni and Di Capua 2012). Geoscience, with its methods, objectives, reference values and ways of thinking about nature, is not only a corpus of technical and scientific knowledge, useful for solving the complex problems of management of the planet, but is also an essential cultural support that should accompany the practical response to those problems.

As asserted by Henri Poincarè (1854-1912) and others, science is a fundamental aspect of culture. Since geoscience is science, this implies it is part of culture (Peppoloni 2012). Indeed geoscience, through its discoveries, visions, methods and definitions, has made and makes culture, by building the constellation of concepts to be used to understand the world (Seddon 1996, Raab and Frodeman 2002, Peppoloni and Di Capua 2012).

Geo-education is the activity that allows geoscientists to use those visions, methods and definitions to transfer to others a way of conceiving the cosmos. Scientific concepts and theories such as deep time, evolution and plate tectonics are fundamental keys for interpreting the universe and the observations, technologies and hypotheses through which we perceive reality. Geo-education implies ethical responsibilities. It is not a neutral and value-free activity. It provides a framework for transferring knowledge about forms, processes and products of natural or humaninduced dynamics, past and present, on our planet and other celestial bodies. But it is also a tool for stimulating critical thinking.

Geo-education has a great potential in ethical terms, due to the strong connection between geoscience knowledge and societal benefits. It can shorten the distances between scientists, public audiences and decision-makers, increasing public trust in science, preventing the cultural and social marginalisation of scientists and fostering the development of a 'knowledge-based society', in the best sense of that term (Bobrowsky et al. 2017, Peppoloni and Di Capua 2017a).

This is clearly evident when considering protection strategies against risks, where insufficient preparedness results in low risk perception, exposing communities to greater vulnerability to possible natural phenomena. Citizens are usually considered as passive actors in risk scenarios or in decisions on land management, while in fact they can play a key role (Stewart et al. 2017). They must be empowered to contribute constructively.

Activities grouped under the concept of 'citizen science' (discussed further in chapter 3) are developed with this objective in mind. The Oxford Dictionary[14] defines 'citizen science' as "a scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions". It is a scientific activity in which non-professional scientists voluntarily participate in the collection and analysis of data, the development of technologies or studies of natural phenomena, among other activities. Citizen science is based on the idea that scientific knowledge and communication is not a one-way street (De Rubeis et al. 2015), and that citizens can provide scientists with support, increased capacity and capabilities, a wider range of perspectives, and indeed insights that otherwise may have been overlooked. Citizen science has both great educational and ethical value: the involvement of citizens in scientific endeavour generates knowledge, understanding, awareness and responsibility. Citizens benefit from taking part in research, contributing to scientific evidence and addressing

[14] https://en.oxforddictionaries.com/

local, national and international issues that are relevant to them. In doing so, they can become better equipped to engage in societal debates and influence political choices.

Promoting geosciences in society through geo-education implies introducing innovative methods and tools to teaching, aimed at developing students' and citizens' critical thinking and observational capabilities. Geoscientists involved in geo-education exemplify geoscience practice as a geoethical duty towards society.

2.4.4 Tools for Geoethics-Oriented Practice

As noted above, the translation into practice of geoethical values is represented in professional settings by codes of conduct, which prohibit inappropriate practices and foster proper ones. Codes are a very useful tool to prevent, monitor and control inappropriate practices and policies. But their adoption is not always sufficient on its own to increase the ethical standards of a scientific and professional community. Poor practices, unethical behaviours, research misconduct and conflicts of interest continue to threaten the credibility of the geoscience community (Peppoloni and Di Capua 2017a).

The observance of ethical practices included in such codes should not be confused with the essential ethics education and training that each geoscientist should receive in their university education, to assimilate ethical values and foster high standards of personal integrity and responsibility. It is essential to embody the value before the code, to make sense of an ethical action (Cronin 2017, Peppoloni and Di Capua 2017a). To encourage ethical behaviours in the geoscience community, geoscientists should be motivated to respect professional codes. This means transferring to them the values that lie behind them. Ethics must also constitute a fundamental part of continuing professional development and lifelong learning. Geosciences are based on experience, so the reference values of geoethics that must accompany the practice of geosciences should be constantly redefined and verified in the light of evolving knowledge, experience and context.

The importance of promoting ethical behaviour within the geoscience community was clearly highlighted in the Report of the GSA Presidential Conference held in Oregon in 1997: *"Individual integrity is not enough: to be truly ethical, one must have personal integrity as well as an on-going awareness and insight into the ethical problems existing throughout the geoscience profession. In other words, geoscientists must become alert to, and active in, the subject of ethics in order for the practice of geology to be truly ethical."*

The need to increase awareness of the ethical obligations of geoscience activity was formalised in 2014 by Matteucci et al., with the publication of the 'Geoethical Promise'. It is a Hippocratic-like oath for geoscientists, previously suggested by Ellis and Haff (2009), aimed at early-career researchers and professionals, but also helpful to motivate the geoscience community as a whole. It is a symbolic document to highlight the ethical and social value of the geoscientist's profession, and the cultural and educational power of geosciences. The Geoethical Promise is founded on the idea that a standard or a code cannot be enough to ensure ethical behaviour, and that ethics must be something inherent to one's daily action, a committed adherence to a *modus vivendi et operandi*.

In its formulation, some principles and reference values are stressed: the necessity to be aware of the societal implications of geoscience practice; responsibilities towards society, future generations and the Earth for sustainable development; the obligation to act for the protection of the Earth system and the benefit of mankind; the need to maintain intellectual honesty in conducting one's work, being aware of the limits of one's personal competencies and skills; and the commitment to continue lifelong development of one's geoscientific knowledge.

In 2018, the Geoethical Promise was included as an official declaration during the ceremony for the geological master's degrees in Italian universities, and has been translated into 35 different languages (Peppoloni 2018).

Another significant achievement in building a geoethical thinking has been the release of the Cape Town Statement on Geoethics (CTSG)[15] in 2016. This document provides a definition of geoethics, sets out its purpose, scope and fundamental principles, and outlines its application and the ethical responsibilities of geoscientists in the context of global challenges. It is founded on a coherent conceptual framework structure, and constitutes an important step in promoting geoethics to the wider geoscientific community and beyond (Di Capua et al. 2017).

The CTSG aims to focus the attention of geoscientists on the development of shared policies, guidelines, strategies and tools, with the long-range goal of fostering the widespread adoption of ethical practices in the geoscience community. It encourages geoscientists to raise awareness of their responsibility, to strengthen the credibility of geosciences in order to secure societal trust in the light of global challenges, and to reaffirm an ideal dimension to the geoscience profession, going beyond simple personal success.

The global impact of the CTSG on the geoscience community has been assured by the support of many international geoscience organisations. Its translation into the most widespread languages worldwide (Peppoloni 2018) has emphasised the importance of sharing universal values and creating a common professional identity across diverse societies and cultures.

One of the first concrete applications of the values expressed in the CTSG has been the 'White Paper on Responsible Mining', released in December 2017 (Arvanitidis et al. 2017).

The White Paper addresses values, concepts and best practices to be considered in mining activity from the perspective of sustainable development. It is an orienting document, aimed at

[15] http://www.geoethics.org/ctsg

providing essential reference elements to frame mining activity in an ethical perspective, and to urge different stakeholders to ensure that geo-resources are extracted and used responsibly. This requires the protection of natural environments by minimising the impacts of mining activities, increasing respect for local populations and awareness of their needs (Groulx et al. 2017), the adoption of high standards and improved health and safety conditions in the working environment, as well as the development of innovative technologies and the implementation of environmentally and socially sensitive best practices.

The White Paper highlights that *"responsible mining demonstrably respects and protects the interests of all stakeholders, human health and the environment, and contributes discernibly and fairly to broad economic development of the producing country and to benefit local communities, while embracing best international practices and upholding the rule of law".*

2.5 A 'Responsible Anthropocentrism'?

It is evident that the biotic and abiotic components of the Earth system (including humanity) are closely interlinked. Some authors have gone further, arguing that our planet essentially behaves like a single living organism with its own physiology and metabolism. Pierre Teilhard de Chardin (1881-1955) and Vladimir Vernadsky (1863-1945) theorised on the development of the Earth, from the geosphere (inanimate matter) to the biosphere (living matter) to the 'noosphere' (the sphere of human thought – a concept discussed further in the following chapter), and the interconnectedness of these systems. In 1979, James Lovelock developed the 'Gaia hypothesis' in his book 'Gaia: A New Look at Life on Earth' (Lovelock 1979), in which he conceived the Earth as a complex and living super-organism capable of regulating itself. Although not universally accepted by geoscientists, as in the case of the paleontologist Peter Ward and his 'Medea hypothesis' (Ward

2009), it has been profoundly influential on Earth systems science, and our growing understanding of feedbacks between life and the planet and appreciation of their significance.

The hypothesis of Earth considered as a single living system has over time been the key point of reference for many ecological visions. Today, the idea of humanity being part of a greater whole, encompassing the planet and all living things, is undoubtedly influential on the growing recognition that we must pay greater attention to the environment and its protection. But this conception is certainly not new. For example, Seneca (4BC-65AD) in the *Naturales Quaestiones* (III, 15, 1) writes: *"placet nature regi terram"* (meaning "it is a shared opinion that the Earth is supported by Nature"). In describing his idea of the Earth system, he compares the water that flows in a river with the blood flowing in human veins and with the lymph that flows along the trunk of a tree. Two thousand years later, this analogy invites us to reflect on the fact that all things belonging to the Earth system (living or otherwise) are closely connected. It is up to human beings to consider this close connection while taking decisions about the environment and our interactions with it.

The extent to which humanity now affects the Earth system, including the geosphere (referring here, and throughout this volume, to all abiotic elements of the Earth system – not just the solid Earth), is reflected in the proposal currently under consideration to declare a new human-influenced geological epoch – the Anthropocene. This notion is contested and criticised, and not only on geological grounds or among geoscientists (see Cuomo 2017, for example) – as are 'anthropocentric' world views more generally. Even more contentious are explorations of whether a 'good Anthropocene' is possible and what this might look like (Preiser et al. 2017). This is perhaps unsurprising given the utopian optimism of some 'ecofuturist' scholars who embrace the term and are convinced that human ingenuity and technologies will be able to fix and control natural systems (Asafu-Adjaye et al. 2015, Bohle 2017). But other scholars explore the concept of the 'good Anthropocene' in a more nuanced and inclusive way, fully recognising that, while we already live in a world that has been irreversibly changed by human intervention, we must do all in our power to understand and minimise our future impacts and shape a future that addresses the needs of people, communities and ecosystems (Biro 2015, Dalby 2016, Pereira et al. 2018). The question of how humankind should live responsibly in such a world is explored in greater depth in the next two chapters.

Whether or not the Anthropocene is formally recognised as a new geological epoch, however, humanity is now undeniably a significant geological force acting on natural environments. A worldview that fails to acknowledge the central role of human impacts on Earth systems and the need for humanity to take responsibility for this is simply one of denialism (Jonas 1979). The unavoidable reality of anthropogenic change makes a degree of anthropocentrism a necessity.

Geoethics encourages geoscientists and wider society to become fully aware of humankind's role as an active geological force, and of the huge ethical responsibility that this implies. It also provides professional geoscientists with the tools to work for the good of society and the planet as a whole in order to meet this responsibility, through ethical behaviours and practices, respectful of all humanity, as well as geodiversity and biodiversity (Peppoloni and Di Capua 2017a). With its emphasis on individual and collective responsibilities of human actors (geoscientists and others), geoethics can help guard against fatalistic or opportunistic acceptance of anthropogenic change, and against human wants and needs (especially those of the wealthy) being given primacy at the expense of impacts on wider systems that might otherwise be framed (by those wishing to brush over environmental concerns) as simultaneously peripheral and inevitable.

What is at stake is not the survival of the Earth, which will be able to absorb the consequences of human activities, but the wellbeing of living things and ecosystems, people and communities, and perhaps the very existence of humanity on the planet. To ensure that we survive and thrive, the first step is to empower people – geoscientists and others - to be responsible. Geoethics has a vital role to play in achieving this.

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