Output 1 (O1)

Theoretical aspects of geoethics and geoethics in georisks

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1. INTRODUCTION
(by Giuseppe Di Capua)

This intellectual output has been prepared as a result of the 1st workshop of the project GOAL, that was held in Rome (Italy) at the INGV – Istituto Nazionale di Geofisica e Vulcanologia (Italian Institute of Geophysics and Volcanology), from 30 July to 3rd August 2018.

The aim of the workshop was to (a) aligning participants to current definition of geoethics, its theoretical aspects, historical background, future developments; (b) presenting a geoethical perspective in georisks management and in geohazards and georisks mitigation policies; (c) exploring citizen science experiences, educational aspects, sociological and risk communication perspectives in the defense against natural risks, based on Italian and international experiences.

In particular, regarding (a) the Italian team, due to its specific expertise on geoethics, has provided a wide overview on this emerging field of geosciences for developing a shared view on the current state of research on geoethics among project participants, aimed at creating a common conceptual substratum/background and sharing values, concepts, online resources and tools in geoethics to be used in the subsequent phases of the project.
Regarding (b) and (c), the workshop in Rome has provided numerous insights about the delicate topic of the georisks management, with a focus on general and cultural aspects, sociological matters, geoscience communication and geo-education problems, citizen science contribution to disaster risk reduction.

Moreover, a detailed overview on geoethical aspects related to the activity of EPOS, the European Plate Observing System, a long-term plan to facilitate integrated use of data, data products, and facilities from distributed research infrastructures for solid Earth science in Europe, has been proposed as a concrete example on how much complex and problematic are the ethical implications related to modern scientific activities and networks.

Finally, a tangible and innovative output of the joint efforts to create resources for higher education courses on geoethics has been announced. It will consist of the preparation of a set of "video-pills" on some important aspects of geoethics to be used as an "Introductory course on geoethics" for early-career professional geoscientists, in order to make them more aware about the ethical and social implications of geoscience research and practice. The discussion about issues and contents of the video-pills has been started up during the workshop as a follow-up of the projection of short videos released by other international projects, whose subject is geoscience, designed for different target groups, that were showed with the aim to encourage the discussion on geoethical aspects of geoscience communication and education.

All representatives of the project partners and other workshop participants, external to the project, have actively contributed to the discussion and to the development of shared contents regarding the topics of the workshop. The first workshop of the project GOAL has been an important occasion to sum up fundamental concepts and values developed in geoethics research in the last years and to start a discussion and exchange opinions and ideas about ways on how to teaching geoethics.

In the next sections, essential contents presented and discussed during the workshop are provided, with a focus on philosophical, theoretical, and social aspects of geoethics and geoethics in georisks management, touching issues like citizen seismology, sociological implications, risk communication and geoscience education, relationships between diverse stakeholders. These contents are essential to ground a geoethics syllabus in the mainstream of the current geoethical thinking and analyses developed by IAPG – International Association for Promoting Geoethics (http://www.geoethics.org), official partner of the project GOAL, and its network.

2. FRAMING GEOETHICS: DEFINITION, CONCEPTS, METHODS AND TOOLS
(by Silvia Peppoloni and Giuseppe Di Capua)

2.1 Introduction: Three fundamental questions to start a geoethical discussion

Humans are capable of modifying natural environments, and in virtue of this prerogative they have an ethical responsibility towards the planet. Indeed, studying and managing the Earth system, exploiting its geo-resources, intervening in natural processes are actions that involve great responsibilities towards society and the environment, of which perhaps geoscientists are not sufficiently aware. Only by increasing the awareness of this responsibility, can geoscientists work with wisdom and foresight, and respect natural processes and dynamics existing in nature while guaranteeing a sustainable development for future generations. In order to define acceptable solutions to current global challenges, geoscientists need to take into proper consideration the ethical and social aspects involved in geoscience issues.

Geosciences (or Earth sciences) are a wide set of scientific, basic and applied, disciplines (including engineering disciplines) whose aims, methods, tools are used by geoscientists to investigate the Earth system in order to understand its composition, structure, forces, processes, dynamics, cycles, resources, evolution, in different spatial and temporal scales and intervals.
The term “Earth system" is here referred to physical, chemical, biological Earth’s constituents and their interacting processes and cycles on both the Earth surface and its interior, capable to transform and/or transfer matter and energy throughout the whole system in ways that are governed by the laws of conservation of matter and energy. The Earth system consists of geosphere (the solid Earth), atmosphere, hydrosphere, and biosphere.

Geosciences analyse the interaction between Earth constituents, the relationships between the planet Earth and other celestial bodies, the influence of human activities on the geological deposits, processes, dynamics, and the ecosystem. Geosciences investigate both abiotic and biotic phenomena, the active and passive interaction between biological and a-biological processes and dynamics (e.g. corals and coral reefs, or biological matter and oil formation), how animal and vegetal life, and humans can determine or influence rock and geologic deposits formation and modifications. Geoscience studies use direct and indirect methods to make observations and get data, and through models geoscientists provide deterministic or probabilistic scenarios to forecast the spatial and temporal occurrence and evolution of physical, chemical, and biological phenomena.

Geoethics was born to define a conceptual substratum of categories, useful as framework of reference for geoscientists, to help them develop a new way of thinking and interacting with the Earth system. Geoethics widens the cultural horizon of geoscience knowledge and contributes to orient scientists and society in the choices for a responsible behavior towards the planet.

At the present geoethics is recognized as an emerging field in geosciences, but until 2012 geoethics was still in its early stage, with fragmented and discontinuous initiatives.
This means that it was necessary to start to give a theoretical structure to geoethics, to assure its scientific credibility, supported by a solid conceptual substratum, by answering essentially to the following questions:

1) *What is geoethics?*
2) *What is the geoscientist's responsibility?*
3) *How can geoscientists serve society?*

2.2 From ethics to geoethics

Practicing geosciences has important implications in ethical and social terms, and geoethics can be a way for us to approach the global problems affecting the human interaction with the Earth system in a more responsible way, without prejudices and ideological constraints. This implies geoscientists being aware of their ethical and social responsibility and role.
Unfortunately, training designed to increase this awareness does not yet exist and cultivating geoethical thinking is usually delegated only to personal initiative. Concretely, universities should train young people to develop critical thinking in geosciences, providing them with conceptual tools, useful to give a satisfactory answer to the following basic questions:

- *When I am faced with a professional problem, on which elements can I base my decision?*
- *What is right to do and why?*
- *And how?*

This is the ethical issue, and it implies a conscious choice between different options in problem-solving.
"*Ethics reflects on the conduct of humans and the criteria on which to evaluate behaviours and choices, in order to identify the "true good", including the means to achieve this goal. Ethics is intended to clarify, for a given circumstance, what to do and how to do it, taking into account the consequences of that act. Its function is to guide humans when they need to make a choice, by providing them with a framework of reference values, shared by the social group to which they belong, that can lead to the good, or to what is most useful to the individual or society. With regard to a profession, we can define ethics as the identification of duties and rights that regulate a professional activity by members of a social group, who possess specific technical-scientific knowledge, as well as methods and tools for its application.*" (Peppoloni S. and Di Capua G., 2017, see Papers in Appendix I - Selected list of references on geoethics).

In the field of geosciences, the more specific term "*geoethics*" is used to frame the ethical problems related to the geoscience research and practice.
"*Geoethics*" is the union of the prefix "*geo*" and the word "*ethics*". An in depth etymological analysis has highlighted that the word "*ethics*" has a double meaning: on the one hand, "*ethics*"

contains a sense of belonging of each human to the social dimension of existence; on the other hand, "*ethics*" is related to the individual sphere of human behaviour.

In these both existential conditions (social and individual) the etymological root of the word "*ethics*" points out human beings responsibilities towards oneself and towards the social community to which they belong.

The prefix "*geo*" clearly refers to the "Earth". But as indicated in Peppoloni and Di Capua (2014) its ancient Sumerian base "*ga*" contains a deeper meaning, that is "home, dwelling place" (Peppoloni and Di Capua, in: Wyss and Peppoloni - Eds, 2014, see Books or Special Volumes in Appendix I - Selected list of references on geoethics). So "*geo*" is not simply the Earth, but more specifically the place where humans dwell and where future generations will dwell. So, geoethics means responsibility towards the Earth and future generations.

Based on these considerations, geoethics has been defined as "*the research and reflection on the values that underpin appropriate behaviours and practices, wherever human activities interact with the Earth system*" (Peppoloni and Di Capua, in: Peppoloni et al. - Eds, 2017, see Books or Special Volumes in Appendix I - Selected list of references on geoethics). This definition proposes an analytic approach to reality, focusing on the need to identify values on which to base the growing interaction between humans and the Earth system.

The second part of the geoethics definition states that "*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*" (Peppoloni and Di Capua, in: Peppoloni et al. - Eds., 2017, see Books or Special Volumes in Appendix I - Selected list of references on geoethics). It emphasizes the centrality of geosciences as a body of technical-scientific knowledge to correctly manage this interaction. In particular, geoscientists are asked to assume the ethical responsibility to use their knowledge for the benefit of society.

2.3 The four levels in the geoethical analysis and areas of application of geoethics

The geoscientists' responsibility can be referred to 4 different levels of analysis:

- the responsibility towards oneself in conducting the own work to the best of own ability. This implies to apply appropriate research methods, verify the sources of information, report findings and interpretations fully and objectively, assure ongoing professional training and the continuous improvement of geological knowledge lifelong, always maintaining intellectual honesty at work, avoiding conflicts of interest that could compromise the trustworthiness of own work;
- the responsibility towards colleagues, to cooperate with a respectful and honest attitude, with the common goal to find solutions to problems. This includes to respect others' ideas, diversity of perspectives, expertise and methods, foster the mutual understanding, accept a fair debate with hypotheses and theories that disagree, share information and data, be respectful of the intellectual property;

- the responsibility towards society that geoscientists have the duty to serve in order to allow its development and assure its safety. To achieve those goals it is fundamental making data and results of own studies public, easily accessible and user friendly with explanatory information targeted to the population, transferring advanced knowledge to industry and authorities, collaborating in the training of technicians' and professionals' skills, participating in educational campaigns for the population, increasing the synergy with government agencies and local administrations through the development of operational protocols;
- the responsibility towards the planet (Earth system). Geoscientists have the knowledge, expertise, professional and cultural sensibility to protect natural environments, to use prudently geo-resources favouring as much as possible a sustainable and responsible management, to enhance the scientific, educational, cultural and aesthetic dimension of the bio- and geodiversity, to entrust it to future generations.

These 4 levels of the geoethical analysis represent a helpful framework to motivate geoscientists to develop a responsible approach to the Earth system, and to increase the awareness of their individual and social responsibilities.

Geoethics applies to the entire range of geoscience fields, such as: responsible/sustainable use of geo-resources; geo- and anthropogenic risks reduction and prevention; management of the land, coastal areas, seas and open oceans; socio-environmentally sustainable supplies of energy; pollution and its impacts on health; climate change studies and adaptation; research integrity and deontology; literacy and education in geosciences; geodiversity and geoheritage protection and enhancement; forensic and medicine geology, etc.

2.4 Key-points of geoethical thinking

Talking about geoethics is possible only by referring to human behaviours. So, geoethics starts from an anthropocentric vision, that has human responsibility as ethical criterion. In fact, humans have the power to choose, more or less consciously, between different options. The definition of geoethics proposes humans, who are themselves part of nature, having the role of rational conscience of the Earth system architecture (Peppoloni and Di Capua, in: Peppoloni et al. - Eds., 2017; Mogk et al., in: Gundersen – Ed, 2017; see Books or Special Volumes in Appendix I - Selected list of references on geoethics).

Geoethics requires conscious and responsible geoscientists to be applied. They possess the knowledge to understand the best way for humans to interact with the Earth system. And even if this knowledge is not perfect, thus fallible, always subject to possible changes and improvements by definition, as any other empirical science, geoscientists have the responsibility to provide excellent science (Marone and Peppoloni, in: Peppoloni et al. - Eds., 2017, see Books or Special Volumes in Appendix I - Selected list of references on geoethics).

In geoethics the concept of responsibility is central. The word "*responsibility*" derives from the Latin verb "*respòndere*", that means 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 be intended not only in legal terms (for example: if calculations to make a slope stable are wrong owing to negligence and a disaster occurs, scientists will pay for the consequences). A penalty for failure is also the loss of credibility, the failure of the scientific and cultural role of geoscientists to guide society in facing geological problems, that is, definitely, the loss of the reason for being geoscientists (Peppoloni and Di Capua, 2017, see Papers in Appendix I - Selected list of references on geoethics).

The importance of the concept of responsibility implies the need to define the perimeter of the geoscientist's action and therefore to identify the role that a geoscientist must play in the decision-making chain. Regarding this aspect, a paradigmatic example is the "L'Aquila earthquake-case" (Cocco et al., in: Peppoloni and Di Capua, 2015, see Books or Special Volumes in Appendix I - Selected list of references on geoethics). In the judgment at first instance, 7 scientists were convicted for negligence in the seismic risk assessment, after the city of L'Aquila had been destroyed in 2009 by an earthquake and three hundred people died. The lack of clarity on the role of the various actors involved (decision-makers, scientists, mass-media and population) led to a confused message to citizens about the risk they were running and about the preventive actions to be adopted. But with the third and final judgement, 6 out of 7 scientists were acquitted, and this made it clear that negligence cannot be attributed to scientists who only had the role of "scientific advisors" and not of decision-makers. So, the distinction of the roles is fundamental.

2.5 The values of geoethics

Once the role of geoscientists has been defined, the need to identify reference values arises, values able to guide choices and behaviours, appropriate for each situation. The ethically correct solution to a problem will not be the result of a simplistic choice between right and wrong. In fact, preliminarily it is necessary to discuss and fix reference values on the basis of which it is possible to discriminate correct/acceptable decisions and choices from incorrect/unacceptable ones.

Three groups of values have been proposed, as useful references to establish a correct/acceptable relationship between geoscientists, society and the Earth system (Peppoloni and Di Capua, 2016, see Papers in Appendix I - Selected list of references on geoethics):

- Ethical values: they concern both the individual and social sphere of geoscientists, and include honesty, integrity, awareness, accuracy, cooperation, inclusiveness, courtesy and fairness.
- Cultural values: geosciences are capable of influencing current and future ways of thinking about the Earth system. The geoethical thinking enhances cultural values such as geodiversity, geological landscape, geoheritage to strengthen the relationship between communities and the land they inhabit, and considers those values also under a socio-economic perspective (as well

as ecological and geological). Geoparks and geotourism, that represent a synthesis of those values, can become a modern economic opportunity for a country's sustainable development.

- Social values: geosciences are a tool to help society in facing great challenges, such as climate change adaptation, the search for new sources of energy and the best management of the current ones, the need for a sustainable approach to the environment, the defense against geo-hazards and the promotion of preventive approaches to georisks management, and the development of a society of knowledge. Values such as sustainability, prevention and education are social values, capable to influence the societal vision of future decades. "Sustainability" has a double social value: in the near term it consists of developing strategies and technologies for reduced use of energies and minerals, and to encourage the percentage increase of renewable energies; in the long term, it consists to building a new model of economic development for our societies that aims to give new generations the possibility of discovering and exploiting other ways to produce energy and use natural resources. In fact, a sustainable world is also economically beneficial to society as a whole. Geosciences can help define the threshold of a sustainable human living.

  The concept of "prevention" has clear social implications. The development of a "culture of prevention" in the society is the way to improve the resilience of human communities, on the basis of scientific information and data provided by geoscientists.

  "Geo-education" has the goal to train young people and to transfer geologic knowledge to the public. Through geo-education geosciences assume a fundamental role in building a knowledgeable society, by raising awareness about how the Earth system operates and evolves.

2.6 Codes of ethics and ethics of responsibility

The translation into practice of geoethical values is represented by codes of ethics/conduct, which prohibit wrong practices and foster correct ones. Codes are a very useful tool to prevent, monitor and control inappropriate practices and policies. But their adoption is not always sufficient to increase the ethical level of a scientific and professional community at an acceptable level. "Bad practices", "unethical behaviors", "research misconduct" or "conflicts of interest" continue to threaten the credibility of geoscience community.

The observance of ethical practices included in the codes should not be confused with the essential ethics education and training that each geoscientist should receive in the university education to assimilate ethical values and reach a higher level of integrity within the professional community. It is essential to embody the value before the code, to make sense of an ethical action. To encourage ethical behaviours in geoscience community, young and early-career geoscientists should be motivated in respecting professional codes. This means that teaching geoethics should be introduced in university curricula (Peppoloni and Di Capua, in: Peppoloni et al. - Eds., 2017, see Books or Special Volumes in Appendix I - Selected list of references on geoethics.

2.7 Intellectual freedom as an fundamental prerequisite for geoethics

Geoethics implies a conscious and rational way of acting, being based on responsible behaviours and a scientific approach to problems. An ethical decision can only come from a responsible choice, but without intellectual freedom ethical decisions are problematic. Intellectual freedom is a fundamental pre-requisite for acting ethically. Without resorting to extreme cases, even harassment, bullying, discrimination, conflicts of interest, pressures at work threaten the serenity of the working environment and more generally they inhibit the freedom of choice. A respectful working environment is fundamental to maintain a high level of professionalism and to assure an ethical conduct while practicing geosciences. Harassment (from psychological to sexual) and discriminations offend the dignity of the person, and seriously undermine not only integrity and credibility of the geoscience community, but also the quality of the scientific results. These kinds of behaviours prevent individuals, driven by fear of punishment or retaliation, from taking ethical decisions.

2.8 (Geo)ethical issues and dilemmas

A (geo)ethical issue presupposes the existence of a choice between two alternatives, one of which is the best option, taking into account the reference system of social, scientific, economic and cultural values in which a geoscientist is acting, assuring an accurate knowledge of the problem to be faced and an adequate competence for its resolution. If one option is clearly better than another, then the decision to be taken could be relatively simple. But often geoscientists are in front of ethical dilemmas: so a “perfect” choice is not possible, but rather different options to be followed exist, all with inevitable negative impacts on society or the environment.
In this case, which is the best choice to be taken from an ethical point of view? On what do geoscientists base their choices?

A real ethical dilemma implies a problematic solution: in fact, it doesn’t have a “perfect” solution, but rather the most acceptable one concerning a specific context.
Moreover, if a geoscientist usually makes choices trying to look at the most acceptable solution (that means the one with the best consequences, or at least not the worst ones), sometimes bad consequences must be carefully evaluated and eventually accepted.
In any case, not always it is a duty of geoscientists to take a final decision about a specific matter. In fact, often the decision on the feasibility of a geological intervention in an area can depend not only on scientific and technical considerations, but also on political issues. In this case, geoscientists have the social role to provide decision-makers with all the exhaustive elements to take a decision as sustainable as possible for that social and environmental context. This means that a geoscientist is ethically obliged to properly inform those who are really in charge of the decision-making process, and surely a solution or at least an orienting suggestion or an expert advice are expected from geoscientists.
If geoscientists are facing a geoethical dilemma, their first professional attitude should be to accept they cannot offer a unique right solution, but options and potential outcomes and scenarios. Geoscientists’ duty is to explain the choices and the consequences of choosing each of

them, avoiding making the mistake of considering geoscience knowledge as a universal law, thinking they might solve an ethical dilemma by using categories like “right” or “wrong”. Geoscientists can suggest (geo)ethical decisions by justifying them adequately from a scientific and technical point of view, and by clearly indicating pros and cons of the choice they are proposing, including when possible a cost/benefit analysis even in societal and environmental terms, taking into account also the probabilities of occurrence of the perturbations induced in the considered system and the quantification of the epistemic uncertainties of their models.

Making technical-scientific choices under uncertainty inevitably implies accepting compromises, trying to find a balance between different factors. So, there is no “absolute good”, even in geoethics. There is only a “good” choice/decision/practice that is related to the circumstances and social, economic, and cultural contexts in which geoscientists are operating. In practical terms, certainly geoscientists’ decisions should consider scientific and technical aspects, as well as economic and temporal implications (for example lesser costs or shorter feasibility time). But at the same time, they should take into account the greater social benefit their choice can entail. Finally, geoscientists will take care of environmental aspects, by choosing interventions that respect as much as possible natural dynamics.

In this perspective, a careful and rational analysis of a problem to be solved must lead to that point of equilibrium, in which the sum of the positive effects is optimized. This would be the way to take a choice ethically sustainable for the human community and the environment involved, based on identified common values, shared by all those who will be involved in the consequences (positive or negative) of that choice.
This implies the importance to work with communities and stakeholders to determine where there is reasonable alignment of values (economic, social and ethical values) and opportunities for collaborative action that will create sustainable benefit for all parties.
Those reference values should take into the due account different cultural, economic and social contexts and backgrounds, existing in different parts of the world. Just as an example: a dam can strongly impact on a natural habitat, but at the same time it can ensure protection from floods and water supply for thousands of people. Similarly, in developed countries it is common to consider mining a threat to human health and nature, but mining is surely an opportunity for development of economically depressed areas, capable to bring benefits, jobs, facilities and infrastructures to the local population.
Positive and negative aspects should be considered at the same time, and also from different perspectives: in the short and long term, or on a small and large scale.

The aim of a geoethical analysis is to find an acceptable solution, a compromise solution, not limited in time, based on scientific but also economic and social considerations, discussed among parties and shared. It is evident that geoethics means not only to define standards and procedures, but to constantly search for universal values to be shared, because probably a technical solution alone is not enough to solve complex problems: real progress is possible when the practical action is accompanied also by an ethical reflection on the value of that action.

2.9 Why do we have to act (geo)ethically? Geoethics as an advantage

In order to favour the spread of (geo)ethical behaviours and practices in the geoscience community, advantages in acting ethically should be highlighted and fostered.
It becomes central to educate to understand the advantage of following ethical rules and best (geo)ethical practices. Conducting geoscience activities in a responsible way means to be able to find wiser and cheaper technical solutions, it means to win the trust of the client/population and earn professional/scientific credibility and respectability. At the same time it is important to create cultural, social and legal conditions, so that there is no advantage for scientists, companies or single professionals to act unethically, because of the negative repercussions on their reputation or in terms of penalties. This doesn't mean to minimize the intrinsic value of an ethical action, but its beneficial aspects should also be emphasized while teaching geoethics.

2.10 Teaching geoethics

The practice of geosciences often places scientists in front of situations for which there are no unique solutions. This implies that decisions related to geoscience matters having (geo)ethical and social repercussions depend on different aspects like the following:

- the reference values existing in the contexts in which geoscientists are operating;
- the level of knowledge, scientific and technical preparation and updating of scientists and professionals;
- the degrees of freedom geoscientists have, depending on whether they work in industry, in the research field, in governmental bodies;
- the efficaciousness of their interaction with other professional figures;
- the perception of the social utility of their actions.

Given the complexity of the issues, it is clear that the ethical dimension in geoscience cannot be entrusted only to the individual sense of responsibility, but it is necessary to develop this dimension in the academic context.

Introducing students and early-career geoscientists to geoethical thinking means transferring to them the values that are behind the concreteness of their scientific action. Geosciences are based on experience, this implies that the reference values of geoethics, that must accompany the practice of geosciences, should be constantly defined and verified in the light of the concreteness of practical results.

Insights:

See Appendix I, II, III

3. GEOETHICS IN GEORISKS MANAGEMENT
(by Silvia Peppoloni)

3.1 Introduction: geoscientists as social actors

Georisks (risks determined by natural phenomena induced by geological dynamics or human activities) are of great interest for the geoethical reflection due to their strong impact on society and enormous repercussions on the development of many countries, where the costs of geological disasters constantly hang over the economic situation. Dealing with georisks from a geoethical perspective means to analyse ethical and social aspects in their management, in science and risk communication towards different stakeholders, in geo-education.

Over centuries, disasters have always scared populations, but the proper dissemination of scientific knowledge and an adequate preparedness can help to find strategies for mitigating their effects. Nowadays the scientific and technological progress can assure us a good level of safety. Obviously the damage due to geo-hazards is not entirely avoidable, but can be greatly reduced through prevention and mitigation efforts, through an effective information and education of society.

Geoscientists need to become more aware of being not only scientists or professionals acting in their fields of interest, but also social actors working for the common good. Geologists, engineers, and in general experts of the Earth system, possess the scientific knowledge and preparation to bring science closer to society.

In the field of the disaster risk reduction, geoethics fosters the proper and correct dissemination of the results of scientific studies; develops and promotes geoeducational tools for the population; aims to improve the relationships between the scientific community and the other stakeholders of the society during all the different phases that characterize the disaster cycle (phases of prevention, emergency and recovery).

3.2 Defining risk

Risk is defined as the symbolic product of hazard, vulnerability and exposure. It is quantified such as the loss produced on an element or group of elements at risk as a consequence of the occurrence of a given phenomenon of a given intensity. The hazard is the probability that a phenomenon of a given intensity occurs in a certain area in a given time interval. The vulnerability is the capability of an element to resist to a given phenomenon. The exposure is the value of the elements at risk (in terms of human lives, economic or historical-artistic values) in a certain area.
These factors have been introduced to analyse the impact of natural phenomena on mankind and their effects are quantified using mathematical tools (included the probability calculus and the evaluation of errors and uncertainties).

Nowadays scientists are able to predict, with some degree of uncertainty, the onset and development over time of some natural phenomena. Moreover, the progress of science is giving new tools to defend people against natural and anthropogenic risks: new methods for the continuous monitoring of phenomena, early warning methods and technologies, efficient building techniques to ensure safety, adequate prevention programs, land management programmes, education campaigns for citizens. All these activities are grouped under the term "prevention".
At the same time, science doesn't provide absolute certainties. In fact, especially in relation to geo-hazards, elements as uncertainty and probability affect the way in which scientists can manage the risk. For example, for the current level of scientific knowledge, it is impossible to establish at the same time when, where and how strong an earthquake will occur. Nevertheless, this doesn't mean solutions reducing the risk cannot be found.

3.3 Geoethical values for building a disaster risk reduction strategy

Where a georisk is present, it is essential to assess costs and benefits of developing a risk mitigation strategy also considering a time perspective. In fact, a strategy which today may seem wasteful could be effective in a larger time interval, by evaluating its likely positive outcomes.
Prevention is the best way to protect population from georisks, but unfortunately, with few exceptions, modern societies don't perceive it as a value, and what is worst, politicians don't tend to support and promote prevention activities that will give fruits in the long term.

The duty of geoscientists, as experts of georisks, is to transfer the value of prevention to society, by emphasizing cases of good land management and consequent reduction of disaster potentiality. Prevention has to become the rational and responsible answer to the right of safety of each citizen.

Ability, individual and joint responsibility, collaborative attitude, reliability, transparency, solidarity, non-discrimination, and impartiality are fundamental values that allow scientists to develop a good science, that is the prerequisite in the strategy for an effective disaster risk reduction. But, in order to increase the resilience of a community (i.e. the societal ability to respond to a disaster, by restoring material and spiritual conditions existing before the natural event), scientists have to work so that values such as prevention (intended not only in terms of cost savings, but mainly as a social and cultural attitude that gives its fruits in a short, medium, and long term perspective), safety, sustainability, education take root into society and become a common societal background. Only if geoscientists inform and educate citizens, the defense against georisks can be possible and effective. The proper dissemination of scientific knowledge and an adequate preparedness of population can help to improve the resilience and so to reduce the risk. Geo-education is a tool to shorten the distances between scientists, population and decision-makers, avoiding the loss of confidence in science by citizens, avoiding the cultural and social marginalization of scientists and fostering the development of risk reduction strategies that are really effective and widespread. Not investing in prevention means to transfer irresponsibly the social and economic costs of a disaster on future generations.

3.4 Georisk reduction as a societal challenge: roles and responsibilities of actors involved

Risk reduction requires an all-of-society engagement and partnership, as clearly indicated in the guiding principles of the Sendai Framework for Disasters Risk Reduction (https://www.unisdr.org/we/coordinate/sendai-framework).
The defense against natural risks involves many actors: not only geoscientists, but also decision makers, local authorities, government agencies, mass media, citizens.
All these actors form a "defence system", that have to act with a common goal and in the same direction, each of them with a specific role, commitment and responsibility in relation to an impending risk. Only the good relationships among them can guarantee a coordinated effort and consequently the efficiency during all the phases related to the disaster cycle. A proper georisks management requires that each role is well-defined and governed by shared operational protocols, especially during the emergency phase, so that overlapping and misunderstanding among different actors don't jeopardize population safety and economic activities.

Geoscientists have the responsibility to conduct an updated and reliable scientific research, which provides a detailed analysis of the epistemic uncertainty for a more effective evaluation of the errors in the prediction models. Scientific models used for studying risk scenarios must be well-grounded on observational data, including clear indications of uncertainties, and discussed within the scientific community. Furthermore, geoscientists have the commitment to improve their ability in scientific communication, through the use of a simplified language but scientifically correct and suitable for different users. Their commitment should be also to maintain good relationships with decision makers and media, so that a multifaceted management of criticalities is possible.

Decision-makers are responsible for natural hazards prevention and mitigation policies. Unfortunately often they have completely different skills than those required by their role. So, they often ignore the limits of scientific studies regarding the prediction of the hazard and the level of seriousness with which a warning could be issued to the public. Sometimes they demand to geoscientists to provide deterministic scenarios, while only probabilistic ones are possible.

Mass media represent the link between scientists and society. During a crisis they should have the duty to give people correct information, necessary for the management of the emergency. They should make themselves responsible for sending public demands and expectations to politicians. Unfortunately, usually journalists have a poor qualification in geosciences. In addition, the language they use is quite different from the language of scientists. So, it happens they can misuse sentences and declarations by scientists out of the context in which they have been stated, and in the worst cases they transform the meaning of the scientists' words in a sensationalistic way. The time of the media communication is different from the time of science: scientists need time for their research and to disseminate scientific results, while often journalists need the scoop, so discussions about the limits of scientific researches and results are not adequately considered.

Citizens are usually considered as passive actors in a risk scenario, while they can play a key role. But among citizens there is a scarce preparedness on scientific matters and this implies their incapacity to defend themselves from georisks by investing on the own safety to increase individual and societal resilience. A scarce preparedness produces a low risk perception and consequently a lower resilience of the community as a whole. On the one hand citizens have the legitimate right to demand actions in defense of their safety, but on the other hand they have also the necessity and the duty to properly inform themselves about georisks.

A more prepared society in scientific terms, well-informed about the possible causes and effects of phenomena, would be able to discern the quality of the media information and force the media to become conscientious spokesperson of the social instances. Moreover, prepared citizens would be capable of evaluating choices of whom manage the territory and to demand from them more efficacious actions. A virtuous circle would be triggered, in which all the actors involved would assume the ethical responsibility of their role.

3.5 Citizen science

Activities relative to the new concept of "citizen science" are developed with the objective to make citizens aware of the active role they can play in the defense against georisks, with the long term goal to improve the resilience of a community.

The Oxford Dictionary (https://en.oxforddictionaries.com/) 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 or para-scientific activity in which non-professional scientists voluntarily participate in the collection and analysis of data, in the development of technologies, in the evaluation of natural phenomena. Citizen science is based on the idea that knowledge is not a one-way road, and citizens can also give to scientists a support, providing them with precious insights that otherwise would have been overlooked.

Various scientific fields and disciplines are involved, and among them also the field of natural hazards. Regarding the seismic risk, some tools have been carried out for involving citizens and using them as a primary source of information. This is helpful for the scientists, to better develop actions for the risk management, and even to obtain valuable testimonies on the earthquakes in themselves, especially for those events that are, by nature, transitory: when they occur, usually no scientist is on the spot, ready to record them. But local people are there and so can have the ability to help by collecting data onsite to be scientifically analysed (for a detailed example on contributions of citizen science in natural hazards studies see the section 4).

The involvement of citizens in scientific endeavour generates knowledge, understanding, awareness and responsibility. Citizens benefit from taking part in research, from contributing to scientific evidence and to address local, national and international issues, and through that, they can become potentially able to influence political choices.

3.6 How geoscientists can support society in the defence against georisks

A society scientifically unprepared prevents the development of risk reduction actions really effective and widespread, and as consequence, the improvement of the resilience. To fill this gap, geoscientists are called to developing appropriate educational strategies, disseminating scientific knowledge, transferring correct and timely information on georisk scenarios and consequences of unpreparedness. The adequate preparedness can help to better face the fear of a disaster and to better react for minimizing damages.

Experts have the duty to make society aware that science cannot be the solution to all problems, but it can provide helpful tools to defend human lives, although accompanied by a certain level of uncertainty.
In particular, geoscientists should:

- conduct their studies verifying sources of information, adherence of results to observations and related uncertainties and errors;
- make data and results of their studies public, open access as much as possible and user friendly, with explanatory information targeted to final users;
- organize a communication strategy before, during and after the emergency phase;
- transfer advanced knowledge and technology to different disaster risk reduction actors, such as industry and authorities;
- participate in educational campaigns for the population, paying attention to simplify concepts, without making them banal;
- try to not transfer absolute certainties but also the limits of methods used, allowing citizens to develop a critical attitude to better understand the decisions taken to face hazards;
- increase the synergy with government agencies and local administrations, through the development of operational protocols;
- assure an ongoing professional training;
- collaborate in training technicians and professionals;
- develop a multidisciplinary approach to problems.

Insights:

See Appendix I, II, III

4. AN EXAMPLE OF CITIZEN SCIENCE: THE MACROSEISMIC QUESTIONNAIRE

(by Patrizia Tosi)

4.1 A false sense of security as an effect of globalizing media information

The globalization of information disseminated through reports by mass media spreads knowledge about earthquakes all over the world. This process may induce the feeling that a strong earthquake is always confined to a faraway location ('the other side') respect to reader/listener.
Unfortunately, instead of disseminating the idea that a strong earthquake is a real possibility in seismic prone areas, those reports give a false sense of security to population and self-reassuring opinions may be generated such as: 'We are different from distant lands. They have earthquakes; we do not have earthquakes'.

Moreover, the earthquake is usually considered the cause of a disaster, and its effects are enhanced by a somewhat spectacular sense and dramatization. The general impression is a basic separation between non-seismic ("peace" periods) and seismic ("war" periods) time intervals: "seismic" negation occurs during non-seismic times, while dramatization, desperation and suffering occurs during seismic times. Spreading scientific knowledge amongst population and raising its scientific awareness is necessary to build new bridges between geosciences and society in order to fill that polarization and achieve a real and more responsible perception of the seismic problem.

4.2 Crowdsourcing to increase the social credibility of scientists

In this perspective, crowdsourcing (collecting information/data from numerous independent individuals) is a modern way of doing science: when a strong earthquake occurs usually a team of seismologists make surveys in the epicentral area in order to assess the level of building damages for deducing the seismic intensity of the shaking. For this activity the expertise is essential, because there is the necessity to discriminate between different engineering structures and building materials. But, looking at the macroseismic intensity field of a strong earthquake, it appears that the greatest part of the territory is interested by low macroseismic degrees and thus by transient effects. The investigation of large areas by teams of experts is a very expensive job. On the other side transient effects are felt or observed by people, and there isn't the need for particular competence to describe them. Moreover, strong earthquakes (with Magnitude ≥ 5.5) are not frequent, but smaller magnitude events, that most of times are felt by citizens, occur every week.

For this reason in 1997, in Italy a small group of seismologists created a website for macroseismic data, one of the first in the world, where people could fill in a simple questionnaire, describing the effects, produced by a seismic shaking, occurred in their own village. Data were elaborated more or less by hand and macroseismic maps were published online after some days. People were immediately happy to contribute to collect observations.

In 2007 this team created a new website "Hai sentito il terremoto" (in English, "did you feel the earthquake") at http://www.haisentitoilterremoto.it/. Currently this website collects data through an online questionnaire that asks to describe the effects individually observed by each user. After the occurrence of an earthquake, citizens voluntarily fill in the questionnaire. Automatically, macroseismic maps and data are generated and published on the website, and updated as soon as new data are progressively available (Fig. 1).

The macroseismic team offers the possibility to users to become permanent members of a community of interested people who are alerted immediately after the occurrence of an earthquake within or close to the area where they live. Currently, more than twenty-six thousands of citizens, located all over the Italian territory, are registered as macroseismic correspondents to the aforementioned website. Every correspondent and occasional user record the local observed effects of an earthquake and then a global map of the felt macroseismic intensities is generated by the online system in almost real-time. Those maps are greatly appreciated by the population, that have the possibility to contribute to collect observations of scientific interest under the supervision of a public research institution.

Sometimes people have doubt about the independence of scientists from politics, claiming that for a conspiracy the "true" magnitude of an event is higher than that assigned by seismologists, while they are more confident about data coming directly from citizens. By "opening the doors of science" to citizens, scientists can get trust by them, increasing their social credibility.

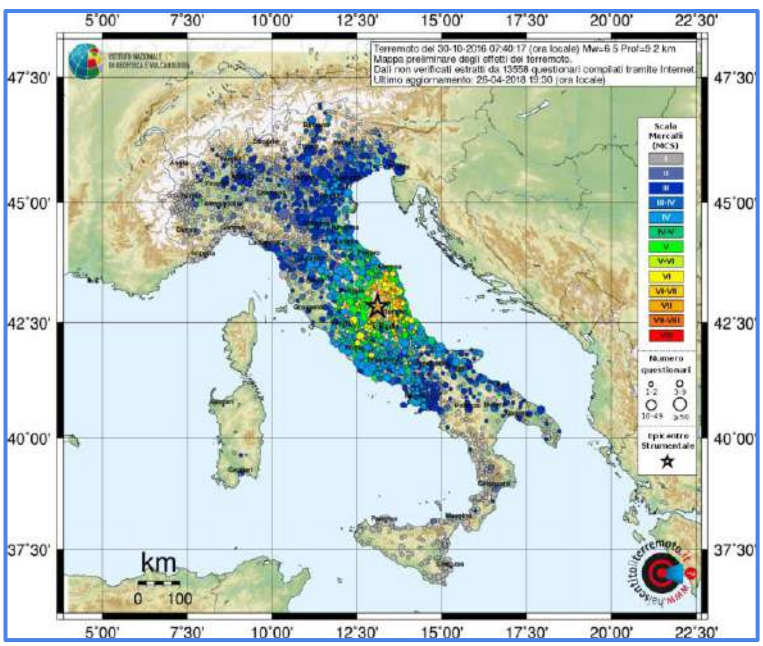

Fig. 1: Intensity Map (MCS) of the October 30th 2016 earthquake in Central Italy generated through online questionnaires filled in on the "Hai sentito il terremoto" (in English, "did you feel the earthquake") website ([http://www.haisentitoilterremoto.it/)](http://www.haisentitoilterremoto.it/).

4.3 Key-points of the citizen seismology

a) Through citizen science (in this case, citizen seismology), geoscientists have now information about even small events, that previously were disregarded.
b) One of the peculiar aspects of gathering data from citizens is that a great quantity of data is collected in a very short time. Usually, at half an hour after a seismic event, the first macroseismic intensity map is generated by collecting six questionnaires. After one day of observations the map is basically generated through several hundred or even thousands of questionnaires.
c) Moreover, rapidity in generating and publishing results is fundamental, since after an earthquake people search for instant information.
d) Obviously people's observations, unlike instruments, are not always correct and data can be flawed. For this reason, some rules to filter out low quality questionnaires have been created. In this way, questionnaires with too few answers or with answers that reveal contradictions in the description of effects are deleted. Initially, among the filtering rules seismologist checked if the macroseismic intensity assessed by using the questionnaire was too high or too low in comparison with the expected macroseismic intensity for a village, because they were not sufficiently confident of data coming from people. Progressively seismologists became aware of the potential of having a lot of questionnaires and the possibility to discover unexpected phenomena to be investigated. For example, in 2014, an earthquake occurred in Greece. It was generated at a depth of eight kilometres and, theoretically, it shouldn't have been felt in Italy. But questionnaires demonstrated the opposite.
e) People who are informed through emails about the events occurred in their area become more aware of the seismicity of their territory, since the 'alert service' is a sort of reminder that earthquakes are continuously present, even if high magnitude events rarely occur. In this way, the word "earthquake" is no longer synonymous with death and destruction.
f) After a strong earthquake or during seismic swarms, people can receive many emails, that are sent by the online system of the website, but these alerts not necessarily affect the appreciation, most of them do not. This seems to demonstrate that the need of people to be informed is strong. In 2015 the automatic localization systems of the INGV – Istituto Nazionale di Geofisica e Vulcanologia (Italian Institute of Geophysics and Volcanology) failed to calculate the magnitude of an event occurred in Sicily. To an earthquake of magnitude 0.9, it was assigned magnitude 5.0 by mistake. Some minutes later the problem was solved, but, automatically, the software managing the website "hai sentito il terremoto" had already sent hundreds of emails to correspondents in Southern Italy. Some hours later the seismological team managing the website sent another email of excuses, being afraid of the reaction. But the comments received in reply showed that in any case people were happy to have been informed and to have the possibility of contributing. It was an occasion to show their appreciation of the seriousness, the precision, and the correctness of scientists in showing their errors and to review their data.

5. CITIZENS SENSORS
(by Elena Rapisardi)

5.1 The dialectic between passive participation and proactive collaboration

The web 2.0 (also defined as Participative and Social Web), will be remembered as the radical transformation in the information and communication domain, whose impacts on the society as a whole are still ongoing and unknown in details. In this framework, "*Do we, as scientists, need to concern ourselves with whether or how the information is used?*". Definitively, the answer is "Yes", but with some precautions. The web 2.0 is a platform, where people can cooperate, share and exchange information at unprecedented speed. Citizens become producer and consumer of information and can be involved not only in communication processes but can also become "sensors" (e.g., by collecting field data through mobile phones) and can also actively participate in democracy.

Very rapidly, this phenomenon has revealed a side effect: an "information deluge" that, in case of natural disasters, unveiled the crucial issue of validation and trustworthiness of the information produced and exchanged by the web users. This issue underlines that knowledge vs non-knowledge can make the difference: everybody must have access and freedom of information, but to participate effectively the content of information need to be exchanged and understood.

In this perspective, the consequence is that non-knowledge threats democracy.

5.2 The main goal of geoscience communicators

In this critical scenario, which is the main goal of geoscientists when delivering information? Giving access and facilitating the use of science-based information, making people more competent users of scientific information. The challenge, as geoscientists, is to make sure that geoscience is effectively shared, with the right level of context and accessibility.

Geoscientists should also protect the vital role that geosciences play in human life, health, safety, economics, and governments.

So, to improve communication, geoscience communicators should be able to build a relationship of trust between geoscientists and society. They should also make clear the role and the responsibility of scientists and so the role and responsibility of stakeholders, citizens, politicians, and individuals.

6. FROM "GOOD" INTUITIONS TO PRINCIPLED PRACTICES AND BEYOND: ETHICAL ISSUES IN RISK COMMUNICATION FROM A SOCIOLOGICAL POINT OF VIEW

(by Andrea Cerase)

6.1 A historic perspective

Providing a summary of the evolution of risk communication approaches through the lens of ethical issues is necessary to frame correctly problems, concepts and methods developed on the basis of practical experiences. The growth and the consolidation of risk communication as an independent, cross-cutting discipline appear to be strictly connected to the growing concern for both public's and individual recipients' needs and rights.

The shift from a source-centred approach toward public's engagement can be easily explained as a by-product of social conflicts arisen in the risk arena. Since late sixties the worries for an unfair distribution of power between risk manager and governmental agencies on one hand and citizens on the other hand has been resulting in an increasing tendency to recognize a few non-negotiable values and principles, such as the right to be informed, the right to be heard and the right to participate the decisional processes.

Meanwhile, psychology and social science triggered a great shift toward a new rationale of risk communication, as first evidence on risk perception and understanding made clear that people are everything but irrational and deserve consideration and respect on the part of scientists and experts.

Along seventies and eighties, a huge body of knowledge has been deployed in risk communication strategies, ensuring a not so painless transition from an arbitrary idea, about what risk communication was purported to be, to the world of good intuitions, and then towards a different approach to risk communication, grounded on principled practices and well-established principles arising from robust research evidence.

6.2 Key-points in risk communication

Risk has become a central issue in contemporary social science for some good reasons:

a) It is a key point to address modernization.
b) It emphasizes knowledge.
c) It stresses decision-making and democratic processes.
d) It shows rationality limitations in addressing side effects of decisions.
e) Highlights the multiplicity of values and forms of rationality.

Above all, risk is about future and it's nor neutral neither painless.

6.3 Fundamental characteristics of risk communication

- Risk communication is not a set of practices in search of a theory.
- It requires a highly specialized knowledge and continuous training of communicators.
- Risk communication must not be improvised, as the stakes are very high.
- Implicit assumptions, established practices and unwritten rules should be carefully assessed.

6.4 Turning ethical principles in principled practices

- Everyone has the right to be aware and be alerted of an impending risk and possible disaster.
- If people feel or perceive that they are not being heard, they cannot be expected to listen.
- Messages and strategy must be shaped on empirical evidence rather than on mere supposition.
- Strategies and messages should be always tested. Risk communicators should evaluate and address unintended consequences of bad communication
- Reaching people it’s up to the source.
- Mutual trust is the first attribute of risk communication effectiveness.
- Being prepared to handle with uncertainty and unpredictability.
- Decisions should lie on well researched principles.
- Expertise from psychological and social sciences is at once necessary and indispensable.
- Basic training in risk communication is helpful and recommendable for who is involved in risk assessment, risk management and risk regulation.

7. DEFINING THE ACCEPTABLE LEVEL OF RISK FOR CIVIL PROTECTION PURPOSES
(by Daniela Di Bucci)

7.1 The acceptable level of risk: a political decision

How acceptable risk levels are determined in political decisions and related policies in the field of civil protection, i.e., regarding disaster risks and their reduction at the national and supranational level?
Establishing the acceptable level of risk is a political decision and not a scientific matter. Some behavioral elements which can impede such a decision have to be recognized. Among these, anomalies inherent in intertemporal choices, availability heuristic and mental accounting play a primary role, because they interfere with preferences for selfish versus others' interests and with the evaluation of individual versus community gains and losses. Due to these processes, the political decision-maker, unless to be a statesperson, will easily prefer not to decide.

7.2 Changing the current paradigm of the political decision-making in disaster risk reduction

Political decision-making, however, could be induced by a change of mind in the voters' community. This reorientation of the society's values and interests can be stimulated taking advance from research on social norms, which underlines the role played by some people that drive innovation in a community, e.g., the trendsetters.

The scientific, technical and professional communities have the knowledge needed to address problems in the right way, are aware of the work to be done on the disaster risk reduction and can establish a direct relationship with single trendsetters and statespersons. In this way they can promote decision-making on disaster risk reduction, stimulating interest, providing advice, answering questions, deepening explanations, implementing further requests, building trust. Especially if they do not have any institutional position of responsibility, scientists and professionals can freely motivate and support trendsetters and statespersons with their expertise, being accountable only for their competence and intellectual honesty. No one expects a neutral position from scientists and professionals, but their expertise can be intended as a contribution of transparent and quantified, high-level, scientific information.

Some suggestions to promote political decision-making on the acceptable level of risk could be summarised as follows:

a) Identifying short-term gratifications for political decision-makers who have to be involved in long-term risk reduction policies.
b) Intervening and modifying the current state towards a more diffuse awareness of the need of risk reduction policies by activating trendsetters to promote a change in the public opinion and

stimulating statespersons to implement policies which consider the disaster risk reduction a public good and therefore are willing to make decisions on the acceptable level of risk.

c) Acknowledging the primary role on the previous points played by the scientific, technical and professional communities.

Insights:

Di Bucci D. & Savadori L. (2017). Defining the acceptable level of risk for civil protection purposes: a behavioral perspective on the decision process. Natural Hazards. DOI: https://doi.org/10.1007/s11069-017-3046-5.

8. TERMINOLOGICAL TOOLS AND GEOSCIENCES: THE IMPORTANCE OF IMPROVING UNDERSTANDING

(by Sabina Di Franco)

8.1 Communication: definition and general aspects

"Communication" can be defined as "The activity of conveying information through the exchange of thoughts, messages, or data by speech, visuals, signals, writing, or behaviour." The communication process, to be effective, must be clear, precise, correct and consistent and can be considered complete only when the receiver has understood the message of the sender. Moreover, even if the huge amount of data and information made accessible by Internet is no more a novelty, the need to come to terms with a sort of "information deluge" and the risk of losing meaningful information in the background noise remains.

The language is in itself rich of semantic ambiguity and polysemy and the meaning of each term has a high degree of context-dependency. For example, the word "mercury", depending on context refers to a planet, a chemical element, a Roman god or a famous rockstar.
The above considerations are true in all communication areas and science communication and information are no exception to these rules. In fact scientists need to share information and data with colleagues worldwide, to store and search datasets, to translate their papers in other languages, to teach, to inform and persuade general citizens, stakeholders, media, policy and decision makers, each of them with different cultural background.

Moreover, in the last few years the complexity and plurality of disciplines related to geosciences have increased. The domains of those disciplines, that form a complex interlinking network, are frequently overlapping, and mutual understanding is sometimes taken for granted whereas each discipline has its specific jargon (Vilhena et al., 2013).
For example, a geotechnical engineer will use the term "soil" having in mind properties such as density, porosity and resistance, while an agronomist will use this term considering the organic content and fertility. Moreover knowledge organisation models have shifted to adapt to the increasing complexity from the tree, that was all we need when Diderot and D'Alembert used the tree model as base to represent "Human Knowledge System" in their Encyclopaedia, to the network, a geometrical arrangement more flexible and fit for connecting a knowledge system that is unprecedented in its richness but tangled and interlinked by definition.

8.2 Terminology: from dictionaries to ontologies

What could help scientists and present from drowning in this "ocean" of data and information (Gandomi and Heider, 2015)? Terminology, the science that studies the terms and their use, and terminological tools such as glossaries, thesauri and ontologies (Fig. 2) could be useful to help semantic searches and data retrieval, both for human purpose and use (metadatation, translation, concept understanding, data sharing, and monitoring reporting) and machine-to-machine interactions. Even more when it comes to the complex interlinking network of disciplines that make up the geosciences today (Sinha et al., 2013).

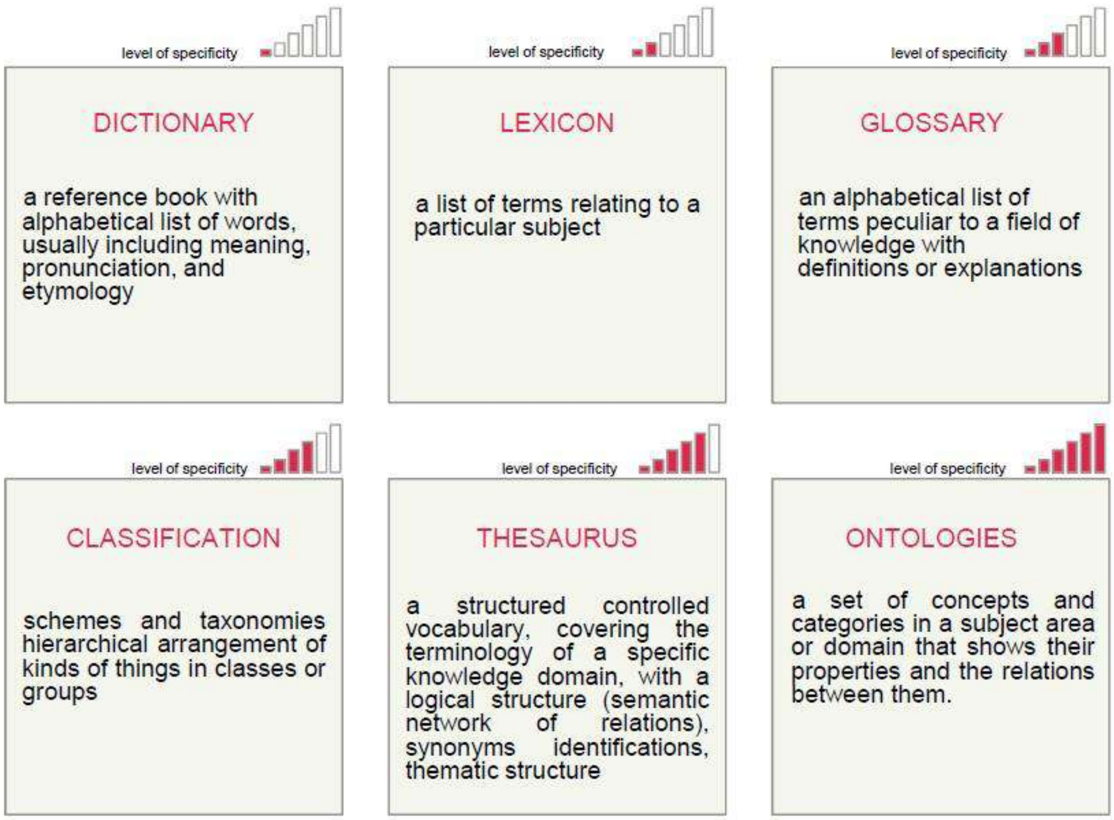

Fig. 2: Terminological tools by increasing level of specificity.

Studies and comparison in other scientific and non-scientific domains reveal that terminological tools integrated in a knowledge management system, help a virtuous data circle for users and providers. For example, in the case of The Unified Astronomy Thesaurus (UAT) attempts to provide a highly structured controlled vocabulary has been proved relevant and useful across the entire discipline, regardless of content or platform (Accomazzi, 2013). As well as for ontologies where “standard ontologies and encodings can be used directly for science data, or can provide a bridge to specialized domain ontologies.” (Richards, 2017).

Finally, frequently it should be remembered that concepts and their representation (words) do not always correspond and sometimes this “semantic entropy” has to be minimised to allow the message be clear, precise and understandable; we need a feedback on tools, knowing if they are useful or not, in order to improve them; to improve mutual understanding we must pay attention in bridging the gaps to avoid misunderstanding that happens even in neighbouring fields of geoscience.

Moreover, some tricky concepts in the communication of science must be carefully considered, such as the concepts of models and probability, prediction and uncertainty, error, time and spatial scale.

Insights:

Accomazzi A., Gray N., Erdmann C., Biemesderfer C., Soles J. (2013). The Unified Astronomy Thesaurus. Proceedings of Astronomical Data Analysis Software and Systems XXIII, part VIII, 461-465.

Gandomi A. and Haider M. (2015). Beyond the hype: Big data concepts, methods, and analytics. International Journal of Information Management, 35, 137-144.

International Organization for Standardization (2011). ISO 25964-1:2011, information and documentation. Thesauri and interoperability with other vocabularies. Part 1: thesauri for information retrieval. Geneva. International Organization for Standardization.

International Organization for Standardization (2013). ISO 25964-2:2013, information and documentation. Thesauri and interoperability with other vocabularies. Part 2: interoperability with other vocabularies. Geneva. International Organization for Standardization.

Richards S.M., Cox S.J.D., Janowicz K., Fox P.A. (2017). Mainstream web standards now support science data too. American Geophysical Union, Fall Meeting 2017.

Sinha A.K., Thessen A.E., Barnes C.G. (2013). Geoinformatics: Toward an integrative view of Earth as a system. The Geological Society of America Special Paper 500, 591-604, DOI: https://doi.org/10.1130/2013.2500(19).

Vilhena D.A., Foster J.G., Rosvall M., West J.D., Evans J.A., and Bergstrom C.T. (2013). Scientific jargon and the flow of ideas. Proceedings of the National Academy of Sciences of the United States of America.

9. GEOSCIENCE EDUCATION AND OUTREACH AS A SOCIAL DUTY: EXPERIENCES AT THE INGV, ITALY

(by Andrea Gasparini)

Since its inception, the INGV – Istituto Nazionale di Geofisica (National Institute of Geophysics and Volcanology), one of the largest research institutions of geosciences in Europe, has developed a strong commitment in scientific communication and outreach oriented to schools and general citizens, and focused on its fundamental research themes, such as the Earth interior, earthquakes and volcanoes, seismic and volcanic monitoring of the Italian territory and the assessment of the relative hazards, the environmental protection.
The main goal of these activities is to increase the awareness of population about natural risks and to communicate which is the role of INGV in the society, also for raising the societal trust in scientific research.

INGV uses various communication channels to transfer scientific knowledge from researchers to different stakeholders, and organizes training courses for scientific journalists and teachers. Population can meet directly researchers and technicians during science festivals, informative meetings, or by visiting INGV offices and museums during open-door day initiatives.

INGV organizes meetings in schools and educational laboratories where students can take part to interactive experiments. In addition, INGV has school partnerships for school-work joint programmes dedicated to secondary students to learn scientific methods and approaches in geoscience research and practice.
Scientific dissemination is the way to spread geoscience knowledge to a wide audience, even through a re-formulation of contents and taking care of language while considering people of different ages and cultural background.
For example, describing the Earth interior to a kid or an adult implies the use of different words and examples; geological events like earthquakes or volcanic activity can be illustrated as a tale or described as real processes. The use of examples from everyday life experiences has a strong impact and is a powerful tool to explain dynamics of natural phenomena (e.g., the mechanism of the convention currents in the mantle is compared to water currents in a boiling pot).
The goal of geoscientific dissemination is not only to inform and educate people. It’s a way to stimulate curiosity and a critical thinking about geological and geophysical issues and methods.

Through institutional websites and blogs, social networks (Facebook and Twitter) and a YouTube channel, the INGV assures a constant and qualified online presence of its geoscientists at the service of the society.

Insights:

Website of the INGV – Istituto Nazionale di Geofisica e Vulcanologia: http://www.ingv.it.

10. ETHICAL IMPLICATIONS OF PROVIDING SCIENTIFIC DATA AND SERVICES TO DIVERSE STAKEHOLDERS: THE CASE OF EPOS RESEARCH INFRASTRUCTURE

(by Carmela Freda)

Addressing ethical issues is nowadays of critical importance for any research infrastructure, initiative or project aimed at providing open access to scientific data and products that concern fields potentially sensitive to stakeholders including not only scientists from various disciplines but also industry, regulatory authorities and the society. This is corroborated by the evidence that ethics has become a very high priority in EU funded research projects.
Indeed, all the activities carried out under Horizon 2020 must comply with ethical principles and national, Union and international legislation. This implies that "*For all activities funded by the European Union, Ethics is an integral part of research from beginning to end, and ethical compliance is seen as pivotal to achieve real research excellence.*"

EPOS, the European Plate Observing System, is an ESFRI (European Strategy Forum on Research Infrastructures) infrastructure serving the needs of the solid Earth science community as a whole. EPOS promotes the use of multidisciplinary solid Earth data to improve the understanding of physical and chemical processes controlling earthquakes, volcanic eruptions, tsunamis as well as processes driving tectonics and surface dynamics. The EPOS mission is to create a single, sustainable, and distributed infrastructure that integrates the diverse European research infrastructures for solid Earth science under a common framework with the final goal of delivering a suite of domain-specific and multidisciplinary data, products, and services in one single and integrated platform.

Numerous national research infrastructures engaged in EPOS are deployed for the monitoring of areas prone to geohazards and for the surveillance of the national territories including areas used for exploiting geo-resources. The EPOS integration plan will make significant contributions to the understanding and mitigation of geohazards, yielding data for hazard assessment, data products for different stakeholders, and services for education and communication activities tailored for the society.

In examining the role of EPOS on openly and freely delivering scientific data and products to diverse stakeholders including but not limited to scientists, ethical issues mainly associated with the use and re-use of these data and products possibly leading to a malevolent use and/or misuse of the data with implications on, for example, national security, environmental protection and risk communication are being carefully evaluated. Moreover, EPOS is aware that the research promoted by the use of data delivered through its platform can have a profound influence on the environment, human health and well-being, economic development, and other facets of societies.

There is nothing intrinsically bad about openly and freely delivering scientific data, since it serves as a tool for leveraging researches leading to solutions for a responsible management of Earth's resources and mitigation of natural hazards.

However, the effects of such a data provision and the obligation to adopt a responsible conduct, complying with regulations, both within the scientific community and in the broader society, exploring the implications of open provisioning of data and services, up to imposing justified constraints have to be considered, discussed and managed.

This requires that contributing to the scientific data and services provision cannot be simply limited to activities fostering the access to scientific products, but must promote innovation in the form of creation of capabilities (i.e., conscious and responsible use of data) and the functioning (i.e., activities constitutive of a scientist's being) to access and use scientific products in an ethically consistent way.

For all these reasons, EPOS has established a specific Working Group on ethical issues in order to define the landscape and the strategies for managing ethical aspects associated with EPOS goals including data and services provision to diverse stakeholders.

Insights:

Website of EPOS – European Plate Observing System: https://www.epos-ip.org/.

11. VIDEOS FOR TRIGGERING A DISCUSSION ON GEOETHICS

(by Johanna Ickert and Silvia Peppoloni)

11.1 Filmmaking as a science communication training tool

The 1st Workshop of the project GOAL has been the occasion to trigger a discussion on different aspects of geoethics through the projection of short videos freely released on Internet by other international projects, whose subject is geoscience. Those videos have been designed for different target groups and can encourage the discussion in particular on geoethical aspects of geoscience communication and education.

The language and the images used, the simple explanations, the particular approach that often starts from simple common experiences taken from daily life, aim to bring citizens and society closer to geosciences. They help to demonstrate the potential of geosciences to improve the conditions of human life, to protect the population from hazards, and to push towards more sustainable choices. However, they are not limited to disciplinary knowledge, but show that geoscientific knowledge is often closely interlinked with socio-political, cultural, ecological, and economic questions.

The videos proposed during the workshop were selected among a set produced by early career geoscientists from the International Training Network "ALErT" (Anatolian pLateau climatE and Tectonic hazards) and the International Research Training Group "StRATEGy" (Surface processes, Tectonics and Georesources: The Andean foreland basin of Argentina) in the framework of a science communication training, facilitated by Johanna Ickert (filmasmethod.com), Dr. Henry Wichura, René Arnold, and Anne Hodgson.

This training aimed to help participants to train their communication competencies through the process of filmmaking and to increase their awareness about the ethical, socio-political and ecological dimension of their research. Evaluation interviews with participants indicate that science video production can be a valuable training tool, enabling participants to attribute form and meaning to their scientific work. The findings demonstrate gains in narrative skills and audiovisual literacy, normative skills including the ability for self-reflection and reflexivity on individual roles and responsibilities, and interpersonal competencies, that involve social learning, empathy, cultural awareness and skills related to working in inter- and transdisciplinary teams.

Given the interdisciplinary character of both training projects, the participating researchers were from numerous sub-disciplines, such as palaeoclimatology, mineralogy, petrology, seismology, geophysics, geochemistry etc., representing groups of diverse age, nationalities, and origins (and with one-third of the course participants being female).

In the next paragraph, for each video is provided a link to look at it and a short description of content to be intended as a starting point for a discussion.

11.2 Videos

The whispering of a mountain (3:28) by Louis Desanois
Source: https://www.youtube.com/watch?v=4J2WmGtxsf8

In this film, a young mineralogist contemplates his field work experiences in an Argentinean mine, where he witnesses several conflicts of interest about the mine's impact on the environment, employment opportunities, land rights, ethical questions etc. Through a personal commentary and deliberately open-ended questions, he critically examines his own role and responsibility as researcher who studies the land and its resources.

The man and the meandering river (4:03) by Marisa Repasch
Source: https://www.youtube.com/watch?v=cJk_1463Ezs
A practical case explained to the public sector: what is the direct impact in real time on the environment as a result of climate change and how do river-dynamics change the landscape and land properties. Through the eyes of an affected farmer in Argentina, the author highlights the dynamics and complexities of river erosion with respect to landscape evolution.

Wonderful Earth (1:44) by Ahmad Arnous
Source: https://www.youtube.com/watch?v=9NVUZHCPCsk
The Earth is a marvellous planet, full of beauty, spectacular landscapes, but also danger and vulnerabilities. This video shows the phenomena of the Earth surface and its interior and mirrors the deep fascination and curiosity of a young geoscientist being involved in the systematics of Earth processes.

Why geosciences? (1:25) by Ershad Gholamrezaie
Source: https://www.youtube.com/watch?v=xAIJi2za2Y8
Do geologists only understand dinosaurs and rocks? No, geologists, with their skills and knowledge, are fully involved in exploring the most important global challenges: climate change, natural hazards (like floods, earthquakes, volcanoes, storms), oil exploration, mining, and sustainability. Geosciences serve to understand how the Earth works: that's why they are necessary. This is a video to overcome clichés and prejudices about geologists and geology and to bring the public closer to geosciences.

The world doesn't work under laboratory conditions (1:30) by Christopher Bernd
Source: https://www.youtube.com/watch?v=ImQEl721Lf0
Models may not coincide with the reality of natural phenomena. The uncertainty factor is always present. It is important to transfer to the public the meaning of uncertainty in science. The value of science exists only if we are aware of its limits.

The North Anatolian Fault (3:57) by Johanna Ickert
Source: https://www.youtube.com/watch?v=y6IxyLe0PKw&feature=youtu.be
Istanbul is located in one of the highest seismic hazard area in the world, due to its proximity to the North Anatolian Fault. This short animated film portraits Olcay, an early career geoscientist, who developed a passion for earthquake science and its communication to the public. Through her personal experience she discovers why her city is so vulnerable to earthquakes, the importance of building respecting anti-seismic criteria and the consequences of unpreparedness to face seismic events by citizens.

12. VIDEO-PILLS FOR GOAL: A FIRST PROPOSAL

(by Giuseppe Di Capua and Silvia Peppoloni)

Short videos ("Video-pills") will be set up in the project GOAL as strategic tools to teaching geoethics. These videos have the aim to introduce audience, in particular early-career professional geoscientists, to essential concepts of geoethics, to be used as starting points for deeper discussions about ethical and social implications of geoscience knowledge, research, practice, education and communication.
Preliminary titles and short notes about the contents of the 5 "video-pills", that will be prepared in the project GOAL, are reported below.

12.1 What is geoethics?

Definition and meaning of geoethics from a philosophical point of view; themes; the concept of responsibility; the four levels of responsibility in the geoethical analysis (the self, collegues, society and the Earth system); ; areas of application of geoethics.

12.2 Values of geoethics

The need to define shared values for taking ethical decisions. The three groups of values proposed for geoethics:

- ethical values: (honesty, integrity, awareness, accuracy, cooperation, inclusiveness, courtesy).
- cultural values: geodiversity, geological landscape, geoheritage (and their practical application in geoparks and geotourism).
- social values: sustainability, prevention, adaptation, education.

Translation into practice of those values through codes of ethics/conduct and the importance of teaching geoethics.

12.3 Ethical issues and ethical dilemmas

The ethical issue as the problem of the choice between two alternatives: elements to be taken into account; reference system of social, scientific, economic and cultural values; the accuracy of knowledge of the problem in technical and scientific terms, and the adequate competence for its resolution. Ethical dilemmas: a choice between different options, all with inevitable, negative impacts on society and/or the environment, and with no right solution in absolute terms, but only with acceptable solutions. Acceptance of consequences and compromise choice. Geoscientists' duty and their attitude in facing geoethical dilemmas.

12.4 Geoethics in georisks management

How geoethics can guide towards a better living with georisks. The concept of "prudence" as defined by Aristotle (384-322 B.C.) and Thomas Aquinas (1225-1274). The defense against georisks as a societal duty (Pirro Ligorio, 1513-1583). The acceptable limit of risk (Giuseppe

Grandori, 1921-2011). The “defence system” against georisks: actors involved and their roles. Geoscientists as social actors. Knowledge and preparedness. Prevention, geo-education, information. Citizens: active actors in the disaster risk reduction. The concept of “citizen science”.

12.5 Responsible use of geo-resources

Essential concepts: identification and engagement of all relevant stakeholders; open, inclusive and continuing dialogue with local communities; reasonable alignment of values; protection of the environment and minimization or mitigation of environmental impacts on people and communities; cooperation closely with regional and local stakeholders better to understand bio- and geodiversity and conservation issues; promotion energy savings and increase the use of renewable energy sources; preventing any environmental contamination; conduct tailor-made and fit-to-purpose research to develop technology innovations and advanced methodologies; providing a safe and healthy work environment for all employees; educating students on the importance of effectively managing geo-resources as well as protecting the environment and assuming social responsibility.

13. APPENDIX LIST

Appendices contain selected resources to be used for going in-depth on contents and concepts developed in geoethics. Moreover the minutes meeting of the 1st Workshop of the Project GOAL is enclosed.

I. Selected list of references on geoethics
II. Reference documents
III. Online resources
IV. Minutes Meeting of the 1st Workshop of the Project GOAL

Appendix I – Selected list of references on geoethics

BOOKS OR SPECIAL VOLUMES

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Appendix II – Reference documents

CAPE TOWN STATEMENT ON GEOETHICS

Preamble

The concepts, values and views on individual responsibilities of geoscientists, expressed in the "Cape Town Statement on Geoethics" reflect an international consensus. The statement aims to capture the attention of geoscientists and organisations, and to stimulate them to improve their shared policies, guidelines, strategies and tools to ensure they consciously embrace (geo)ethical professional conduct in their work.

Introduction

Geosciences have major impacts on the functioning and knowledge-base of modern societies. Geoscientists have specific knowledge and skills, which are required to investigate, manage and intervene in various components of the Earth system to support human life and well-being, to defend people against geohazards and to ensure natural resources are managed and used sustainably. This entails ethical obligations. Therefore, geoscientists must embrace ethical values in order best to serve the public good.

Geoethics is an emerging subject, which promotes a way of thinking and practicing geosciences, within the wider context of the roles of geoscientists interacting with colleagues, society and the planet.

Only by guaranteeing the intellectual freedom of researchers and practitioners to explore and discover in the Earth system, is it possible for geoscientists to follow ethical approaches in their work. Likewise, only by increasing researchers' and practitioners' awareness of the ethical implications of their work is it possible to develop excellent geoscience to serve society and to reduce the human impact on the environment.

Definition of Geoethics

Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system.

Geoethics deals with the ethical, social and cultural implications of geosciences knowledge, education, research, practice and communication, and with the social role and responsibility of geoscientists in conducting their activities.

Purpose

Embracing geoethics is essential: to improve both the quality of professional work and the credibility of geoscientists, to foster excellence in geosciences, to assure sustainable benefits for communities, as well as to protect local and global environments; all with the aim of creating and maintaining the conditions for the healthy and prosperous development of future generations.

Fundamental Values of Geoethics

- Honesty, integrity, transparency and reliability of the geoscientist, including strict adherence to scientific methods;

- Competence, including regular training and life-long learning;
- Sharing knowledge at all levels as a valuable activity, which implies communicating science and results, while taking into account intrinsic limitations such as probabilities and uncertainties;
- Verifying the sources of information and data, and applying objective, unbiased peer-review processes to technical and scientific publications;
- Working with a spirit of cooperation and reciprocity, which involves understanding and respect for different ideas and hypotheses;
- Respecting natural processes and phenomena, where possible, when planning and implementing interventions in the environment;
- Protecting geodiversity as an essential aspect of the development of life and biodiversity, cultural and social diversity, and the sustainable development of communities;
- Enhancing geoheritage, which brings together scientific and cultural factors that have intrinsic social and economic value, to strengthen the sense of belonging of people for their environment;
- Ensuring sustainability of economic and social activities in order to assure future generations' supply of energy and other natural resources.
- Promoting geo-education and outreach for all, to further sustainable economic development, geohazard prevention and mitigation, environmental protection, and increased societal resilience and well-being.

<u>Geoethical Promise</u>

The adoption of the following Hippocratic-like oath (the "Geoethical Promise") by early-career geoscientists is proposed, to promote respect for geoethics values in geoscience research and practice:

I promise…

… I will practice geosciences being fully aware of the societal implications, and I will do my best for the protection of the Earth system for the benefit of humankind.

… I understand my responsibilities towards society, future generations and the Earth for sustainable development.

… I will put the interest of society foremost in my work.

… I will never misuse my geoscience knowledge, resisting constraint or coercion.

… I will always be ready to provide my professional assistance when needed, and will be impartial in making my expertise available to decision makers.

… I will continue lifelong development of my geoscientific knowledge.

… I will always maintain intellectual honesty in my work, being aware of the limits of my competencies and skills.

… I will act to foster progress in the geosciences, the sharing of geoscientific knowledge, and the dissemination of the geoethical approach.

… I will always be fully respectful of Earth processes in my work as a geoscientist.

I promise!

Final Statement

It is essential to enrich the roles and responsibilities of geoscientists towards communities and the environments in which they dwell, as well as paying attention to each scientist's individual conscience and relationships with colleagues. Human communities will face great environmental challenges in the future. Geoscientists have know-how that is essential to orientate societies towards more sustainable practices in our conscious interactions with the Earth system. Applying a wider knowledge-base than natural sciences, geoscientists need to take multidisciplinary approaches to economic and environmental problems, embracing (geo)ethical and social perspectives. Geoscientists are primarily at the service of society. This is the deeper purpose of their activity.

In the coming years, especially when addressing matters like energy supply, use of geo-resources, land management, pollution abatement, mitigation of geo-risks, and climate change adaptation and mitigation, ethical and social issues will be central in scientific discussion and in public debate. In addition, handling large quantities of data, science and risk communication, education strategies, issues of research integrity, anti-harassment and anti-discrimination policies, gender balance and inclusion of those living with disabilities will be major topics for geoscientists.

Raising the (geo)ethical awareness and competences of the members of the geoscience community is essential, also to increase trust and credibility among the public. This can best be achieved in the near future by two means: by promoting more effectively existing guidance such as codes of ethics/conduct and research integrity statements; and by introducing geoethics into geoscience curricula, to make geoethics a basic feature of the training and professional activity of geoscientists.

The Cape Town Statement on Geoethics was prepared during the 35th IGC – International Geological Congress in Cape Town, South Africa (27 August – 4 September 2016)

Drafting Committee: Giuseppe Di Capua, Silvia Peppoloni, Peter Bobrowsky
With the contribution of: Nic Bilham, Martin Bohle, Andy Clay, Emilia Hermelinda Lopera Parejas, David Mogk
Approved by the IAPG Executive Council on 26th October 2016

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THE GEOETHICAL PROMISE

I promise…
… I will practice geosciences being fully aware of the societal implications, and I will do my best for the protection of the Earth system for the benefit of humankind.
… I understand my responsibilities towards society, future generations and the Earth for sustainable development.
… I will put the interest of society foremost in my work.
… I will never misuse my geoscience knowledge, resisting constraint or coercion.
… I will always be ready to provide my professional assistance when needed, and will be impartial in making my expertise available to decision makers.
… I will continue lifelong development of my geoscientific knowledge.
… I will always maintain intellectual honesty in my work, being aware of the limits of my competencies and skills.
… I will act to foster progress in the geosciences, the sharing of geoscientific knowledge, and the dissemination of the geoethical approach.
… I will always be fully respectful of Earth processes in my work as a geoscientist.
I promise!

Proposed in:
Matteucci R., Gosso G., Peppoloni S., Piacente S., Wasowski J. (2014) The Geoethical Promise: A Proposal. Episodes, 2014, vol. 37, n. 3, pp. 190-191.

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WHITE PAPER ON RESPONSIBLE MINING

Preamble

Modern societies are dependent on mineral-based products. Energy technology, Information and communications technology, consumer electronics, infrastructure, logistics and food production all increasingly rely on an ever-widening array of minerals and metals. For example, production of a personal computer or a smartphone needs over 40 elements. Rapid replacement of internal combustion engines by electricity based technology in the car industry and widening application of wind and solar energy may cause a massive demand for mining of metals such as, lithium, cobalt and rare earth elements. The use of many of these hi-tech metals will vastly increase quantities in the future, and mining of primary resources is the only way to produce them. Minerals also provide the materials to build homes, schools, hospitals and infrastructure. Minerals and metals are essential for generating and supplying “renewable” «green» energy and low-carbon production technology. Even wind generation requires huge amounts of traditional minerals and metals including aggregates for their concrete anchorage, copper for the motor windings and transmission cables and aluminium for their construction material. Minerals and metals are also fundamental to make societies more resilient to climate change because of their use in the technologies mentioned earlier.

Mineral and metal consumption strongly correlates with economic growth and urbanization. Three billion additional people will likely move to cities by 2050. Improved recycling, resource efficiency, better product design and new materials will reduce mineral and metal consumption per capita, but mining of primary resources will continue to play an important role in the future in building sustainable societies.

Geology defines the occurrence of mineral deposits so mining is geographically constrained, but the use of the products of mining in down-stream industries or as final products often takes place in continents and countries different from the location of the mine. Therefore, mining communities do not necessarily appreciate the importance of mineral production for the welfare of people living in other countries, particularly if there is no tangible sharing of those benefits.

Mining cannot choose locations that are logistically, socially, environmentally or politically optimal, appropriate or ‘friendly’. This means that companies may have to deal with circumstances that could pose ethical challenges including: the relationship with local communities, position in the landscape/environment, relationship with local and national governments, weak governance and associated increased risk of corruption and bribery. It is necessary to deal with these challenges in a responsible way. This also means that geoscientists and engineers will need to build their capacity and skills on how to deal with local communities and related social issues.

There is no doubt that mining can bring positive benefits to the host countries but these can come at a cost to the environment and local communities if relationships, resources and operations are not managed properly. The fundamental aim must be equitable distribution of the benefits of development and minimization of the negative impacts on people and the environment. Responsibly navigating this field requires a strong ethical compass.

Introduction

Mining often takes place in remote, less developed areas and can provide great opportunities for local development. Wealth generated by mining has the potential to improve the economy, infrastructure and quality of life of the host country, region and community, and brings opportunities for economic growth and diversification. Mining generates revenue for governments through royalty and tax income. It also provides both skilled and unskilled employment, technology transfer and training for people, together with further jobs through economic and social multiplier effects. Mining can bring substantial improvements in physical, social, legal and financial infrastructure. Realization of mining's contribution to the United Nations Sustainable Development Goals (SDGs) requires deliberate and sustained effort. If not properly managed, economic growth and development can come at an unacceptable social and environmental cost. While mining has historically affected its surrounding environment, advances in technology, and improved management techniques and methods make it possible to reduce, even drastically, many negative impacts and thus facilitate a change in the negative perception of the public toward mining activities. The mining cycle consists of the stages public good geoscience studies; prospecting and staking; early stage exploration; advanced exploration and development; construction; exploitation; and closure. Increasingly, mining companies are making efforts to reduce the environmental impact of mining and to minimize the footprint of their activities throughout the mining cycle, including rehabilitation of land and ecosystems after mine closure and dealing with the social aspects of closure. Dialogue between the mining companies and people in the local communities is essential from early exploration to mine closure. Mining companies should build and maintain ongoing productive relationships with surrounding communities through transparency and open dialogue, using best available practices, operating in harmony with other land uses, decreasing water usage, energy intensity and environmental footprint to assure an ethical approach while interacting with the Earth system. Governments should also enhance transparency, provide a stable legal framework, implement policies to share the financial benefits of mining with local communities and the host countries, promote long-term investment in geological surveys as a social commitment and promote mineral exploration to find new resources for future needs.

Definition of Responsible Mining

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.

Purpose of this document

This document intends to provide essential reference elements for framing this important topic from an ethical perspective and to draw geoscientists', companies', policy makers' and society's attention to the ideas and approaches that the actors involved in mining have developed and use.

It thereby illustrates the need for geoethics and, for those working in this field it shows areas in which they can put the values enunciated in the "Cape Town Statement on Geoethics" into practice. This document summarizes the results of an extensive survey of relevant literature. The bibliography lists relevant source documents.

Best Practices for Responsible Mining

When developing and implementing responsible mining practices, consider the following practices and applicable guidelines:

1) Identify and engage all relevant actors (stakeholders), including authorities, community members, employees, contractors and non-government organizations. Maximize contribution to sustainable development, manage and mitigate any environmental risks and impacts, better understand and meet the expectations and needs of society and the political situation, assess social impacts and opportunities, conduct social baseline studies, ensure good governance and maintain high standards of ethics. The latter includes steering clear of bribery and corruption, both of which can have a nefarious impact on community development, company reputation and mining operations and, in a wider context, on the functioning of democracy. Bribery and corruption are global problems and complicity is not specific to developing nations.

2) Conduct open, inclusive and continuing dialogue with local communities throughout the mining cycle, to create strong, transparent, trusting, collaborative and lasting relationships. Pay particular attention to human rights and respect for local culture and cultural heritage, access to land and water, and issues related to employment, security, public procurement, diversity, integrity, and gender equality. The main intent is to establish long-term well-being and sustainable development of local communities that continues after mine closure.

3) Engage with communities and stakeholders and identify areas in which there is reasonable alignment of values (implicitly both economic and moral). Look for opportunities for collaborative action that will create sustainable benefit for all parties, while respecting local cultural values. Aim to make a significant contribution to the local, regional and national economies and to positive and stable social structures. This local employment and procurement may have a strong and resilient economic effect throughout the entire value chain. Appropriate and resilient social structures will contribute to good local governance and community development Governments would share the value created through taxes and investment opportunities for local communities.

4) Protect the environment and minimize or mitigate any environmental impacts on people and communities, including on the use of resources such as energy, water, and productive soils. Commit plan for securing water availability, maximizing water recycling and minimizing fresh water intake, eliminating uncontrolled water discharge, understanding the water-soil interplay and preventing water contamination by implementing new technologies and innovative processes. Also, minimize noise and dust emissions, and prevent land use conflicts. In this respect, actors

should take into account the growing competition between land use, biodiversity and water resources.

5) Cooperate closely with regional and local stakeholders better to understand biodiversity and conservation issues, increase biodiversity awareness and thereby improve biodiversity and natural resource management practices. This helps minimize biodiversity loss and habitat degradation and land disturbance by mining, along with other increases in sensitivities of adjacent ecosystems may occur.

6) Acknowledge the possibility that, when a project does not meet basic environmental and social criteria for acceptance building and operating a mine is not the ‘right’ outcome.

7) Promote energy savings and increase the use of renewable energy sources such as solar panels and wind to reduce carbon dioxide emissions. As mining is a major energy user, it needs to develop new technologies to improve its energy efficiency. Essentially, certain minerals and metals are components of these new technologies and therefore critical to fast progress of the ongoing energy transition towards a low-carbon society.

8) Manage waste in an efficient and safe way, by improving its transportation and tailings management, preventing any environmental contamination, and reusing waste as possible. In this respect, always consider waste as a potential secondary resource. Mining should aim to recover all valuable metals and minimize waste.

9) Plan closure and rehabilitation based on environmentally and socially sustainable standard elements and management systems. Take into account future planning in relation to re-development and new potential uses of the restored land. Closure of a mine requires functional and tested technical and scientific methods, so that the restoration of quarries, tailings, waste areas and infrastructure allows further sustainable use of the area according to plans. Mine closure has a major impact on surrounding communities and planning for the social and economic aspects of the transition should start well in advance. Possible approaches include support of economic diversification and creation of alternate livelihoods, capacity building, professional training, and others. Part of the wealth generated by mining should serve as a catalyst for sustainable development of the communities. All actors involved should anticipate the accompanying changes to the social fabric and manage these as well as possible.

10) Conduct tailor-made and fit-to-purpose research to develop technology innovations and advanced methodologies addressing exploration and extraction of mineral resources in a responsible manner to reduce potential negative environmental impacts.

11) Guarantee access to conflict-free minerals by exploring for potential sources of these minerals outside active conflict zones, or replacing conflict minerals (such as the chemically similar “high-tech” elements niobium, tantalum, and cobalt with ethically and locally produced ones). Raise the societal and ethical issues involved, and consider improving conditions of

producing operations globally. While legislation, both within the European Union (EU) and the USA, is now being enforced to "guarantee" conflict-free niobium, tantalum, and cobalt in industrial products, there still are major caveats associated with the situation.

12) Provide a safe and healthy work environment for all employees, and contribute to the health and safety of surrounding communities. Within the company, organize work in such a way that it is safe and meaningful to employees. Automating certain processes and making them more efficient, as well as developing new practices and working methods in cooperation with the entire staff can help achieve this goal. The need for strict health and safety standards and practices is self-evident, as is education aimed at a good work culture. Occupational safety aiming at zero accidents is an important goal in all development. Assure a respectful and fruitful working environment by eliminating harassment and discrimination based on race, gender, religion or nationality.

13) Educate students on the importance of effectively managing mineral resources as well as protecting the environment and assuming social responsibility, and provide training/coaching in the practice of engagement with communities and other stakeholders', to graduate highly skilled and ethically responsible geologists, mining engineers and environment professionals.

<u>Additional aspects</u>
A recent Atlas published under the United Nations Development Program showed that mining could contribute to each of the United Nations Sustainable Development Goals (SDGs). This requires that companies: (i) include the selected SDGs in their main activities, (ii) clearly state what they are prepared to do, (iii) avoid providing social services that are the responsibility of the government and (iv) work together with all actors involved. Some examples of contributions companies can make are dialogue and commitment to work with all parties involved; participation in sustainable development initiatives; using their ability to convene; and planning processes.

Deep-sea mining is a relatively new field and practical implementation of the principles of responsible mining outlined earlier will probably require considerable thought and experimentation. The types of social and environmental issues raised by deep sea mining are quite different from those related to mining activities on land, and the long term impact of deep-sea mining deserves to be carefully discussed and scientifically approached.

The aspects of responsible mining described above refer to modern industrial mineral exploration and mining. However, artisanal and small-scale mining provide a livelihood to millions of (mostly poor) people worldwide, use primitive methods that often cause severe environmental damage and pose huge risks to health (mainly because of the use of mercury), and produce up to 20% of world gold production and 80% of gem production. The challenges involved in making this type of mining more responsible include poverty, weak states, social issues, and lack of education and infrastructure. Many governments are trying to address the situation, and a number of industrial mining companies contribute by working with organizations of small miners allowing them to work on part of the company's concession and by providing technical and educational support. Artisanal and small-scale mining can be compatible with large mining operations. Providing training, access to technology and enhancing the overall governance of raw materials should be a joint effort of governments, miners and local populations.

Conclusions

Responsible mining concerns the principles and ethics of sustainable development applied to the exploration for and exploitation and use of economic mineral resources, including the entire value chain, from studies, exploration, and extraction to processing, refining, waste management, mine closure and rehabilitation. In particular:

It is about concrete commitment to managing the economic, social and environmental challenges related to mineral resources development, to build a system capable of ensuring/promoting responsible extraction of minerals and developing a proper alignment of the corresponding benefits at local, regional, national and global scales.

It is about how to build trusting and transparent relationships with society in general and with the actors more directly involved that allow a fruitful involvement of local communities and government authorities in the creation of sustainable benefit for all parties.

It is a way to minimize and mitigate environmental impacts related to water, biodiversity and land.

It meets and tackles climate change issues through implementation of innovative technologies across the value chain, but also by producing the supplies of minerals and metals needed in low-carbon energy systems.

For this to happen an open communications strategy along with engagement of all relevant actors is necessary.

The principles expressed through the "Cape Town Statement on Geoethics" are essential for responsible mining. It is clear that there is the expectation that any geoscientist, working in this area will make her or his responsible contribution. The world needs an ever-greater variety and quantity of minerals, the production of which can be very damaging to people and the environment. However, with proper controls, ethics and regulation these negatives can be minimized and the positives, such as development maximized. However, that mining companies do require financial and regulatory stability and access to geodata to achieve these goals.

Responsible mining does not only require actions and commitments from mining companies, but is likewise dependent on the active and constructive engagement and involvement of all actors (including governments). They all have a responsibility to be well informed, transparently updated and fully aware of all aspects of any mining activity that touches them in any way. Social and environmental responsibility is integral and rests on all actors involved.

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The White Paper on Responsible Mining has been drafted by the IAPG - Task Group on Responsible Mining.
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With the contribution of: Vitor Correia, Roberto Lencina, David Ovadia, Mark Rachovides, Ian Thomson.
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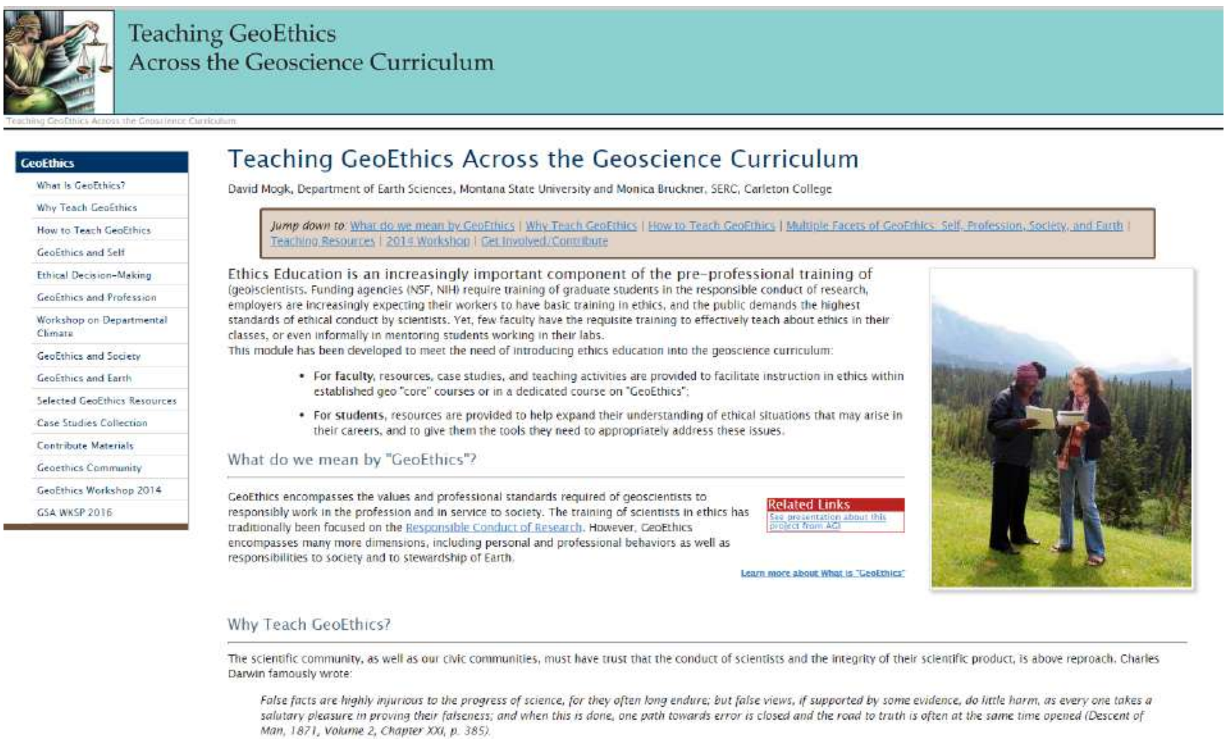
Appendix III – Online resources

http://www.geoethics.org

Website of the IAPG – International Association for Promoting Geoethics.
Links to publications on theoretical and practical aspects of geoethics (books, papers, articles, products); tools (reference documents, codes of ethics and conduct of geoscience organizations); events and initiatives organized worldwide.

https://serc.carleton.edu/geoethics/index.html

Website of the project “Teaching GeoEthics Across the Geoscience Curriculum”.
A sort of online university on geoethics with a case studies collection.



http://croninprojects.org/Vince/GeoEthics/index.htm

Website of Prof. Vincent Cronin, collecting: codes of ethics and professional practice; ethics organizations, centers and institutes, resources online, presentations, writings, textbooks and references

Appendix IV – Minutes Meeting of the 1st Workshop of the Project GOAL

Minutes Meeting of the 1st Workshop of the Project GOAL
"Theoretical aspects of geoethics and geoethics in georisks"
c/o INGV – Istituto Nazionale di Geofisica e Vulcanologia
Rome (Italy), 30 July - 3 August 2018
Summary

Present
Alexandra Cardoso (Universidade do Porto, Portugal)
Beatriz Azanza Asensio (Zaragoza University, Spain)
Clara Vasconcelos (Universidade do Porto, Portugal)
Daniel de Miguel (Zaragoza University, Spain)
Giuseppe Di Capua (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Jūratė Platužienė (Kaunas University of Technology, Lithuania)
Markus Fiebig (University of Natural Resources and Life Sciences, Austria)
Nir Orion (Weizmann Institute of Science, Israel)
Patrizia Tosi (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Ron Ben Shalom (Weizmann Institute of Science, Israel)
Sebastian Handl (University of Natural Resources and Life Sciences, Austria)
Silvia Peppoloni (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Tomas Valatkevičius (Kaunas University of Technology, Lithuania)

External participants
Andrea Cerase (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Andrea Gasparini (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Daniela Di Bucci (Dipartimento della Protezione Civile, Italy)
Elena Rapisardi (Freelance, Italy)
Giuliano Milana (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Lilli Freda (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Pierfrancesco Burrato (Istituto Nazionale di Geofisica e Vulcanologia, Italy)
Sabina Di Franco (CNR-IIA Istituto sull'Inquinamento Atmosferico, Italy)

Apologies
Laura Beranzoli (Istituto Nazionale di Geofisica e Vulcanologia, Italy)

Monday (30 July 2018)

- Welcome by Giuseppe Di Capua (leader of the Italian team of GOAL) and introduction to the 1st workshop of the project GOAL, entitled "Theoretical aspects of geoethics and geoethics in georisks" (***pdf file in attachment: "Introduction_Di Capua_GOAL_July2018"***):
  - ✓ Aims of the workshop and questions for participants.
    - Aims of the workshop in order to create a common background and share values and concepts developed in geoethics: (i) Aligning participants to current definition of geoethics, its theoretical aspects, historical background, future developments; (ii) presenting a geoethical perspective in georisks management and in geohazards and georisks mitigation policies; (iii) showing educational resources and citizen science for the defense against natural risks, based on Italian and international experiences.
    - Questions presented to participants: What is geoethics? What is the geoscientist's responsibility? How can geoscientists serve society? What is the geoethical approach in the defense against natural hazards?
  - ✓ Description of the programme based on lectures, videos, exercises, discussions (***pdf file in attachment: "GOAL_Programme_1st_Workshop_Rome_July-August2018"***). The programme has been developed considering a multidisciplinary perspective and gender balance.
  - ✓ Logistic information and description of gadgets offered by the Italian Team, thanks to EMSO (European Multidisciplinary Seafloor and water column Observatory) and EPOS (European Plate Observing System) research infrastructures, officially hosted at the INGV – Istituto Nazionale di Geofisica e Vulcanologia (National Institute of Geophysics and Volcanology), Rome (Italy).
- Lecture by Silvia Peppoloni (member of the Italian team of GOAL, research geologist at INGV, and Secretary General of the IAPG) entitled "Framing Geoethics: definition, concepts, methods and tools", focused on the definition of geoethics and its cultural and operative implications, topics, aims, and values of geoethics, its historical background and the conceptual framework.
- General discussion on theoretical aspects of geoethics and recent international achievements.
- Presentation by Giuseppe Di Capua on structure, activities, publications and documents of the IAPG – International Association for Promoting Geoethics (http://www.geoethics.org), official partner of the project GOAL and leading organization in developing and promoting geoethics worldwide.
- Presentation by Pierfrancesco Burrato (external participant, research geologist at INGV, Rome) on "Geological and geomorphological evolution of the area of Rome: implication for the growth of a metropolis and its natural hazards". This presentation gives essential information on geology of Rome and its evolution.
- Group debate on and final discussion on topics of the 1st day of the workshop.
- On request of participants, Giuseppe Di Capua will share among GOAL partners some fundamental articles on geoethics published in the last years.

Thuesday (31 July 2018)

- Lecture by Silvia Peppoloni entitled "Geoethics and georisks: ethical and social aspects in disaster risk reduction (DRR)".

- General discussion on several aspects related to georisks management in the framework of geoethics (studies, information, communication, education, science-media-politics-citizenry interface, multidisciplinary approaches).
- Presentation by Patrizia Tosi (member of the Italian team of GOAL, senior researcher, geologist, at INGV, Rome) on “Macroseismic questionnaires and citizen science”.
- Group discussion on the relationship between geoscientists and citizens, bottom-up and top-down interactions, the educative potential of citizen science.
- Presentation by Andrea Cerase (external participants, sociologist at INGV, Rome) entitled “From ‘good’ intuitions to principled practices and beyond: ethical issues in risk communication”.
- Presentation by Daniela Di Bucci (external participants, geologist at the Italian Civil Protection Department, Rome) entitled “Defining the acceptable level of risk for civil protection purposes: a behavioral perspective”.
- General discussion about ethical and social aspects in georisks communication and management, on geoscientists-decision makers-journalists relationships, on the “L’Aquila earthquake case” and the “L’Aquila trials”, on the meaning and implications of the “acceptable level of risk” concept. Conclusive considerations on topics treated in the 2nd day of the workshop.

Wednesday (1 August 2018)

- Presentation by Lilli Freda (external participant, senior research volcanologist at INGV, Rome) entitled “Ethical implications of providing scientific data and services to diverse stakeholders: the case of the EPOS research infrastructure”.
- Group discussion on geoethics in research activities, with a focus on ethics in data management, research integrity and professional ethics, and geosciences-industry interaction.
- Presentation by Andrea Gasparini (external participant, geologist technician at INGV, Rome) on “INGV activities on geoeducation”, with an overview on different experiences and projects developed by INGV in order to increase the trust in geoscientists by citizens, to raise awareness about georisks preparedness, to educate young people to geosciences knowledge.
- Guided visit of the team members and external participants to the INGV seismic monitoring room. Giuliano Milana (senior seismologist at INGV) illustrates the seismicity of Italy and of Central Mediterranean area, the Italian seismic network, managed by the INGV, the functioning of the seismic monitoring room, the protocol followed by seismologists to alert the Italian Civil Protection Department in case of earthquakes.
- Presentation by Elena Rapisardi (external participant, freelance, expert on science communication) entitled “Citizens Sensors: dialectic between passive participation and proactive collaboration” with focus on concepts like communication, consultation, and participation, in particular on one-way and double-ways approaches in science communication, on citizens’ participation in science as scientific information co-producers in order to increase societal resilience to disasters.
- Presentation by Sabina Di Franco (external participant, research geologist at the CNR – Consiglio Nazionale delle Ricerche – National Research Council, Rome) entitled “Terminological tools for Geoscience: the importance of improving understanding” with a focus on general concepts and

values of science communication and different tools at disposal to improve societal understanding of geoscientific knowledge.

- Group discussion on a wide spectrum of ethical and social implications in geosciences and georisks communication and education, on the base of the contents and concepts proposed by speakers during the 3rd day of the workshop.

Weekday (2 August 2018)

- Giuseppe Di Capua informs that a change in the programme is needed in order to get more time for some learning exercises proposed by Nir Orion. This implies that the activity of filling in the questionnaire "what do you know about ethics in geosciences?" is replaced by Orion's exercises. Participants agreed on the replacement.
- In order to explore different tools for teaching geoethics, Johanna Ickert (external participants, not physically attending the workshop, cultural anthropologist at the University of Plymouth and filmaker) gave the permission to project some videos, whose subject is geoscience, designed for the general public. Giuseppe Di Capua invites participants to pay attention to the language and visual techniques used, to the peculiar approach to geosciences matters that often starts from simple experiences taken from daily life. Most of videos were produced in the framework of science communication workshops. Through this videos, Johanna Ickert reminds to the GOAL workshop participants that major international frameworks such as the Sendai Framework for Disaster Risk Reduction (DDR) call for a shift in current DRR practices towards more participative actions and preventive activities. This call has major implications on the way how geoscience communication is conceptualized and carried out. Each video projection is shortly introduced by Giuseppe Di Capua that proposes some hints, in order to focus participants' attention on some aspects that could be of interest for communicating and teaching ethical and social implications of geosciences. Videos trigger an intense discussion after each projection and confirm to be powerful tools to start participatory events in learning activities, under a teacher's guide. Most of videos will be available in the IAPG website (http://www.geoethics.org) in the near future.
- Nir Orion (leader of the Israeli team of GOAL) illustrates, through examples and exercises (***pdf files in attachment: "Natural Learning_Orion_GOAL" and "Geoethics around us_Orion_GOAL"***), the ethics of teaching by following the concept of "natural learning" (participatory and knowledge-building process under a guide), also by discussing differences with the "not-natural learning" approach.
- Group discussion about the results of learning exercises and strategies.
- Clara Vasconcelos (project GOAL leader) distributes to participants and illustrates some examples of syllabus (***rar file in attachment: "Examples of Syllabus"***) in order to start a discussion about the future structure of the geoethics syllabus that will continue and be deepened in the next workshop to be held in Porto at the beginning of 2019.
- Group discussion about topics dealt with in the 4th day of the workshop.

Weekday (3 August 2018)

- General discussion on issues arisen during the workshop: doubts, comments and suggestions for the next workshops.

- General discussion on the questionnaire to be used in order to get feedbacks about GOAL workshops. An initial draft prepared by Clara Vasconcelos and Alexandra Cardoso (member of the Portuguese team of GOAL) is deeply discussed and after the approval of some changes participants agree that Alexandra Cardoso will arrange the online version of the questionnaire that will be filled in by all the participants of the workshop.
- Giuseppe Di Capua illustrates some "lights" and "shadows" in the development of the mainstream of the geoethical thinking (***pdf file in attachment: "Conclusion_Di Capua_GOAL_July2018.pdf"***) and the basic question "*Why do I have to behave ethically?*" is proposed to participants with an exhortation to reflect on possible answers. In addition, final considerations about the five-days workshop are suggested, and all the ideas that have guided the programme preparation of the workshop are recalled.

Rome (Italy), 3 August 2018

Giuseppe Di Capua

Note:

Files indicated as in attachment to the minutes meeting have been not included in this report